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DOUBLE-TRACK WORK ON THE SOUTHERN RAILWAY BETWEEN ALEXANDRIA AND ORANGE, VA.

By John W. Ash.*

GRADING AND TRACKWORK.

In November the Southern Railway completed the work of double tracking that part of its main line between Alexandria and Orange, Va., a distance of 78 miles. During the past summer the Pennsylvania R. R. completed the erection of the new double track bridge, Fig. 1, for the exclusive use of steam railways, across the Potomac River at Washington, D. C., and, as the Southern Ry. operates all trains on the Pennsylvania R. R. tracks between Washington and Alexandria, it may be said that they now have a complete double track line between Washington and Orange, a distance of 85 miles. It is expected that the work of double-tracking the line south from Orange will begin in the near future, but as the Chesapeake & Ohio R. R. Co., which runs its trains over the Southern's tracks from Alexandria, leaves the Southern Ry. at Orange, traffic south of there is not quite so heavy.

When the first contract for this work was let in October, 1901, it was only for reductions and revisions for a single track between Alexandria and Manassas, 26 miles, but the following spring instructions were given to make all revisions for a double track line, and several months later an additional contract was let for grading and masonry for a double track between Manassas and Orange, a distance of 52 miles.

While the entire line was not completed until November, 1904, the greater part of it has been in operation as a double track for some time, for as soon as a stretch of a few miles was graded and the track laid and ballasted, it was put in operation either as a double track or as a part of the single track until summits could be cut down, and sags filled on the part of the o'd line that it paralleled. The first section of about five miles was put into operation as a double track in August, 1903. From that time until final completion, one or more sections of varying lengths were put in operation every month. In this way, and by operating work trains over it before being thrown into regular service, the last section of new line was in good condition for fast running before another section was thrown open.

For the greater part of the distance the old roadbed was simply widened out to full width for two tracks, the width at subgrade being made 34 ft. and tracks spaced 14 ft. on centers. In several places however, where it would have been necessary to grade for a temporary track the alinement was slightly changed so that grading could be done for two tracks, and as soon as ready, one or both of these tracks was put in service and the old track abandoned.

The more important changes that have been made both in alinement and grade are as follows: Between mile posts 13 and 20, 400 degrees of curvature were eliminated and the distance shortened about 2,500 ft. Grades were reduced from 1.50% to 1.0%. In one place the new line crosses the old line 65 ft. higher as shown by the faint light line in background of Fig. 2. Between mile posts 23 and 27 nearly 300 degrees of curvature were eliminated and the distance shortened about 1,500 ft. The grades were reduced from 1.5% to 1.0% as a maximum. Curvature aggregating 38 degrees and 20 degrees was eliminated from mile posts 78 to 80 and mile posts 81 to 82, respectively. The total curvature eliminated for the 78 miles was 790 degrees, 720 degrees being in the first 20 miles. The total distance shortened was practically one mile. The maximum curvature was reduced from 7° to 4°, and the maximum grade was reduced from 1.5% to 1.0%.

Near mile post 68, at Culpeper, the old line passes through a deep cut of a very hard conglomerate. The alinement is rather crooked but as the grades are in the right direction for the loads, it was deemed advisable to make an entirely new and independent cut for the southbound track, making the alinement straighter and the grades lighter than in the old cut. This throws the two tracks several hundred feet apart at the center of the cut, but it allowed the contractor to carry on the work with greater speed and less danger to trains from blasting. This cut is 65 ft. deep at the deepest place and contained 98,000 cu. yds. of excavation. Owing to the irregular and seamy nature of the rock considerable difficulty was experienced from the drills sticking in the holes and having to be abandoned. They usually stuck when within a foot or two of the full depth of the hole. Six steam drills were used on this job and part of the time work was carried on night and day, the work being lighted by electricity from the Culpeper electric lighting plant. The cut was completed in about 14 months from the time work on it commenced. Fig. 3 is a photograph of the new cut looking south; the two overhead bridges shown are highway bridges erected by the railway company, the one on the right spanning the old cut.

The heaviest cut made was near mile post 82. At this place the new line is 10 ft. lower than the

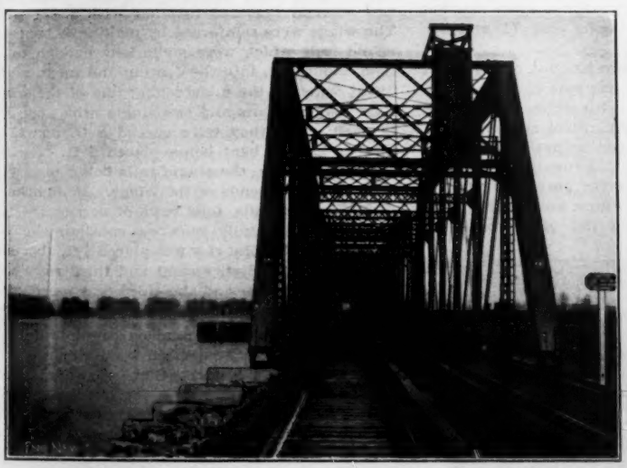


FIG. 1. NEW LONG BRIDGE OF THE PENNSYLVANIA R. R. ACROSS THE POTOMAC RIVER, AT WASHINGTON, D. C.

FIG. 2. ACCOTIUK VIADUCT ON THE SOUTHERN RAILWAY.

*Assistant Engineer, Southern Ry., Austell, Ga.

old line at the center of the cut; the alinement was changed to avoid a reverse curve just north of there and to allow the excavation to be made through the cut wide enough for two new tracks, keeping just far enough away from the old track to allow trains to run safely over it at full speed. This cut contained 125,000 cu. yds., the greater part being classified as rock, the lower 8 or 10 ft. consisting of a compact blue stone, slightly harder than granite. Steam drills were used on this work and all material was loaded by a large steam shovel onto cars hauled by light standard gage engines, the longest haul being nearly 2½ miles. Owing to a large number of delays caused in general from accidents to the dirt trains, the excavation was not completed as soon as expected and the line through this cut was one of the last sections to be put in operation, the work of excavating occupying nearly 15 months.

Fig. 3. Single Track Solid Rock Cut on the Southern Ry., Near Culpeper, Va.

Between Alexandria and Manassas there were several cuts containing from 75,000 to 100,000 cu. yds. but not very hard material to excavate. The total excavation of all classes of material for grading between Alexandria and Orange was 2,200,000 cu. yds.

New 80-lb. rail was laid between Alexandria and Manassas and 85-lb. rail between Manassas and Orange, the Weber joint was used on the 85-lb. rail and a four-bolt joint on the 80-lb. rail. The ballast consists principally of broken limestone from the Riverton and Strasburg quarries, and it was intended to ballast the entire line with broken stone, but owing to numerous delays to the track forces caused by the inability of the several crushers to furnish material for ballast and concrete as fast as needed, the railway company put a steam shovel to work in their gravel pit at Springfield, Va., excavating material for ballast and also for fill and widening of banks at a few minor places. This shovel kept from one to three work trains busy the most of the time.

About every seven miles sidings have been built and the Union Switch and Signal Co. are installing interlocking plants at each of these places. All trains head into the sidings at the tower, and all switches and signals are controlled and manipulated by the towerman. The laying of new and temporary tracks, and sidings, as well as ballasting was done by the railway company's own forces.

BRIDGES AND MASONRY.

All old bridges were taken out and replaced with new and heavier structures, excepting three or four that had been erected during the past few years. The total number of new bridges is as follows: 42 spans of deck plate girders from 30 to 90 ft. span; two spans of through plate girders; one four-span single track through truss; one single span double track through truss; one two span double track through truss; one single span double track deck truss: one 162 ft. span double track deck truss, with 90 ft. girder approaches at each end, and one viaduct 470 ft. long. In addition to the above, four old single-span, single-track through trusses were erected for highway crossings, and one single track one span through truss was taken out at mile post 74 and re-erected at mile post 10.

The work involved a large amount of masonry, and with the exception of one pair of stone abutments that were extended with stone, all masonry work was built of concrete. Steel reinforcement was used on all culverts and arches and a number of abutments; Johnson corrugated bars were used principally, but wherever possible to do so, old rails were used, as in wings, head walls, back walls, etc. The following list gives the total number of openings together with the total concrete yardage:

31 openings with cast iron pipe from 12 to 48 ins.	339	cu. yds.
114 culverts from 2 ft. to 20 ft. span	7,446	" "
3 arches from 20 ft. to 54 ft. span	5,204	" "
22 waterways spanned by bridges	20,383	" "
3 highway undercrossings	1,857	" "
4 overhead highway bridges	478	" "
Total, 177 openings	35,710	" "

The majority of the above openings were extensions of the old masonry, but wherever possible to do so, in making extensions to piers and abutments or where arches were sprung between old abutments, the old masonry was left standing and encased with concrete. By doing this, the old masonry was materially strengthened, and avoided the patched-up impression that a stone structure gives when concrete has been added to it.

Fig. 4 is a photograph of an arch across Pope's Head Creek, near Clifton, Va. This arch has a span of 50 ft., is three centered with radii of 16 ft. 10 ins. for the haunches, 28 ft. 8½ ins. for the center on the intrados, and 37 ft. on the extrados; the rise is 20 ft. and the thickness at crown is 30 ins. the total height from spring to top of head wall coping is 31 ft. The reinforcement for the arch consists of two transverse rows of 1¼-in. corrugated bars spaced 12 ins. c. to c., the upper and lower row being placed three inches from extrados and intrados respectively. No longitudinal ties were used; the ends were lapped 3 ft. and securely fastened together with heavy wires. The wings were reinforced by making A bents out of old rails which were made long enough to extend about 2 ft. into the footing and up to within about 6 ins. of the undercoping line of the wings. Two of these bents and two single rails were used in each wing; they were spaced 8 ft. apart, the first or longest bent being placed 4 ft. from the face of the arch, the single rails being placed towards the outer ends of the wings. In addition to the bents and rails, four rows of corrugated bars were laid horizontally, each row consisting of four ½-in. bars. The first row was placed 4 ft. above top of footings, the first, second and third rows were spaced 4 ft. apart, and the third and fourth rows 6 ft. apart.

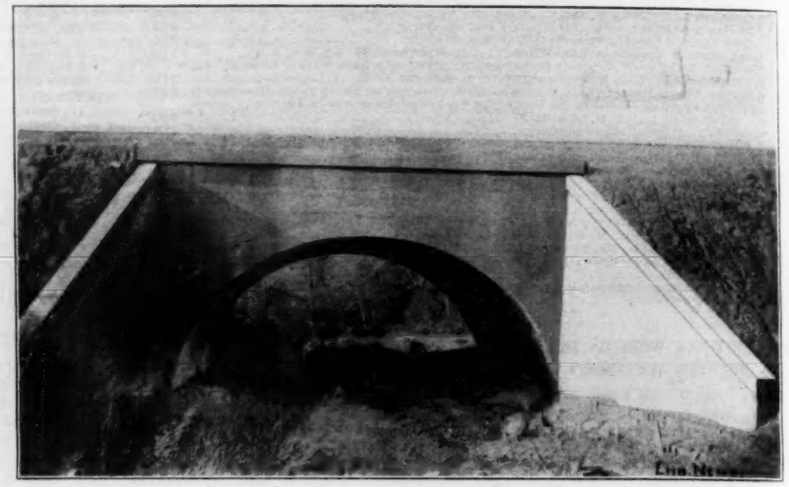


FIG. 4. CONCRETE ARCH ACROSS POPE'S HEAD CREEK, SOUTHERN RY.

FIG. 5. BRIDGE ACROSS THE RAPIDAN RIVER, SOUTHERN RY.

A gravity mixer was used on this job and material for concrete was raised by a steam derrick to an elevated platform that was made large enough to permit materials for one batch being prepared while the other batch was being shoveled into the mixer. The mixer was hung on flanged rollers upon a short length of rail so that it could be easily pushed back and forth along one edge of the platform. Two sets of chutes were made from lumber, and were so arranged that each alternate batch could be deposited on opposite sides of the structure, thus keeping both sides up to the same level; this also permitted the work of concreting to be carried on without interruption, for while the men on one side were placing the concrete flowing down the chutes, the men on the other side could be tamping and spading and getting their chutes in place for the next batch. When the work had been carried up about 8 ft. on each side for the full length of the arch the remainder of the ring and backing was carried over in sections, each section being just long enough to permit it being completed the day it was commenced. The lower row of bars had all been fastened to place before concreting was commenced above the footings, and the work was so arranged that the upper row did not have to be placed until the section had been carried up to within 6 ins.

of its full depth at the crown. The upper row of bars was then placed and made secure and the remainder of the section carried over in one layer. The different classes of concrete used on this job were 1:3½:7 for the footings, 1:3:6 for wings, headwalls and haunches, and 1:2:4 for the arch ring. The total yardage was 1,816 cu. yds.

The centering used was a little lighter than would ordinarily have been used on a similar structure built of stone. Bents were spaced 7 ft.

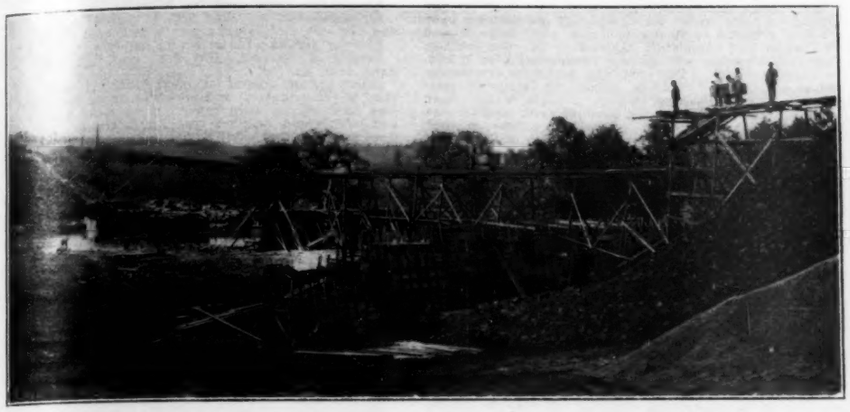


FIG. 6. VIEW OF RAPIDAN RIVER BRIDGE UNDER CONSTRUCTION.

apart and were covered with 4 × 4 in. lagging over which was laid 1 × 6-in. tongued and grooved pine. The covering was kept thoroughly wet ahead of the concreting which made it practically water tight as no appreciable leaks appeared at any time.

Across Kettle Run a similar three centered arch of 54 ft. span was built. It has a rise of 20 ft. 6 ins., a crown thickness of 3 ft., a height of spring about footing of 6 ft. The arch reinforcement was spaced 7 ins. c. to c., the arch being on a skew of 20° to the center line. This arch was built for two tracks and replaces an old single track girder span. The old masonry being in good condition, it was not removed but was incorporated with the new work. The concrete in front of the abutments up to springing line was about 4 ft. thick, and the two down stream wings were encased with concrete varying from 18 ins. to 3 ft. thick on the front. The up-stream wings were left standing and fill made between them and the new wings, the latter extending about 10 ft. in front of the former. After the fill had been made around the arch there was nothing to indicate that it was not an entirely new structure throughout. The total concrete yardage for this job was 2,475 cu. yds., about 300 cu. yds. being saved by using the old masonry.

Fig. 5 is a photograph of the bridge across the Rapidan River at Rapidan, Va. The superstructure consists of a one-span double track deck truss 162 ft. long with 90 ft. girder approaches at each end. The masonry consists of two wing abutments and two piers. The bridge shown in the background is the old two span deck truss now abandoned but later to be removed and re-erected at some other place. A change in line and grade was made between mile posts 78 and 80 and crosses the old line about 8 ft. higher just south of the old bridge, so that the west wing of the old south abutment projected into the line of the new south abutment. The old masonry and foundations were in first-class condition and only a small part of it was torn down and the new abutment built around it, which saved nearly 200 cu. yds. of concrete. Fig. 6 is a photograph of the work in progress; footings are in and forms being built for the north abutment, concreting for pier 1 is nearly finished, the cofferdam for pier 2 is being built and part of the old south abutment is being torn down; the photograph was taken about two months after the work commenced.

All foundations were carried to solid rock; in the north abutment it was found near the surface of the ground, at pier 1 it was 6 ft. below low water level, and at pier 2 and the south abutment it varied from 7 to 10 ft. below low water level. Considerable trouble was experienced in excavating for pier 2. A substantially tight cofferdam of Wakefield piling, with 8 × 8-in. well braced waling, had been driven as supposed to rock, when the water had been pumped out and excavation was well under way, water commenced to rush in, the piling lifted up and in less than a minute the cofferdam was full of water and sand. The piling was redriven and pumping and excavation started again, but after three or four attempts had been made with the same results, another row of single plank was driven all round the outside and about 3 ft. from the first dam; the space was filled with sacks loosely filled with sand and excavation started again; by working next to the piling on the inside of the cofferdam, the material under the sacks gradually forced its way inside the cofferdam and the sacks sank to the bottom and prevented any further breaks. When the excavation reached rock, the surface was found to be very uneven and full of deep pockets that were filled with coarse gravel that the piling had failed to penetrate so that when the water had been pumped out and a lot of material had been excavated the outside pressure gradually dislodged the gravel and forced sand and water through the opening, the rush becoming so great that the sheet piling would be lifted up several feet. After the sand sacks reached the bottom a 10-in. centrifugal pump running half the time had no trouble in keeping out the water.

Fig. 6 also gives a good idea of how the concreting was carried on. A crusher was erected on the fill near the site of the north abutment which crushed rock from nearby cuts for concrete stone. The sand was excavated from a bar lower down the river and hauled in wagons and dumped near the crusher. Cement was unloaded from the cars at the site of the work. Trestle work was built from the end of the fill across the site of the north abutment to pier 1, a track was laid on this trestle and fill, and material was loaded and delivered in cars directly to the mixing platforms, which were high enough to permit the use of gravity mixers without having to be again raised until the structure was nearly complete, the concrete from the mixer running down chutes to where it was deposited.

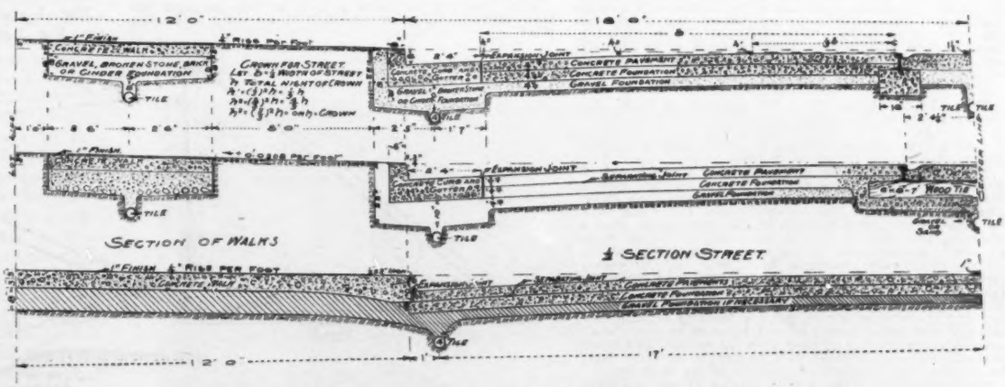
When the concreting was practically finished on the north side of the river the outfit was moved across to the south side and the same method adopted as for the north side. Before all the concrete work was finished on the north side however, excavation for the south abutment and pier 1 was so far advanced that it was deemed advisable to put in the footings as soon as possible so as to be out of danger from a sudden rise of water. A large flat bottomed boat was therefore constructed to haul the stone across the river from the crusher, sand and cement being delivered as on the north side. The work of concreting in these footings had hardly been completed before there came a sudden rise in the river that would have filled our excavations with mud if they had not already been filled with concrete.

The total yardage for this job was 3,482 cu. yds., the classes of concrete being 1:3½:7 for footings, 1:3:6 above footings to undercoping lines, 1:2:4 for bridge seats, and 1:2½:5 for back walls and wing copings.

Between Alexandria and Manassas the general contractors for grading and masonry were Lane Bros. Co. & Jones, of Esmont, Va. W. J. Oliver & Co., of Knoxville, Tenn., were the general contractors for the work between Manassas and Orange. The Phoenix Bridge Co. furnished and erected all new bridges and took out the old structures that they replaced, and all old bridges were erected by the railway company with its own forces. Mr. W. H. Wells, Engineer of Construction, had charge of all the work with Mr. R. F. Ezzell as Resident Engineer. Mr. J. A. Dodson was Superintendent of Construction in charge of ballasting, tracklaying, etc. The writer was Inspector of Masonry, but later became Assistant Engineer in charge of masonry construction.

THE CONCRETE PAVEMENTS OF RICHMOND, IND.

A year ago we published an article (in our issue of Jan. 28, 1904) by Mr. H. L. Weber, city civil engineer of Richmond, Ind., on concrete pavements that had been built in that city. Mr. Weber informs us that he has received a great many inquiries from engineers asking for further information. We are indebted to him for the following data:



CROSS-SECTIONS OF CONCRETE STREET PAVEMENTS, RICHMOND, IND.

We have in this city about 38,000 sq. ft. of concrete pavements, some of which have been down for ten years. Part of these are on alleys and part on streets, which have a great deal of travel. Some of the alleys are in the business part of the city, and have a large amount of traffic.

The work has been done by contract, under the specifications sent you herewith, and under most careful supervision. The cost has been about 16 cts. per sq. ft. As the work has been done in small contracts the cost has

been higher than if the contract was large enough to install labor saving machinery. The work has given universal satisfaction. I enclose some letters from business firms, abutting property owners on one of the streets, which has been down over two years.

Under our system of construction, I would have no hesitation in recommending a concrete pavement for a roadway even for quite heavy traffic. But the methods and plan of construction must be the best, and the supervision very thorough to obtain this result.

The letters referred to by Mr. Weber, and abstracts from his specifications follow:

Mr. H. L. Weber,
City Engineer.
Dear Sir:

In regard to your inquiry as to the cement street on Elm Place, at the back of the "Arlington," we will say that in all ways it is perfect, as it is easily kept clean thus making it sanitary, and although it was put down late in the fall and went through a hard winter, we think it is in perfect condition. If the price of cement is any thing near that of brick, we would use cement every time, as heavy hauling does not seem to affect it in the least.

Yours,
J. P. Iliff & Son.

Richmond, Ind., Aug. 1, 1904.

Mr. H. L. Weber,
City Engineer.
Dear Sir:

In the fall of 1899 we put down a cement driveway through our iron department after we had consulted you and a number of people who had experimented with brick, stone and wooden block, but none of whom were satisfied with the results, and were apprehensive that cement would not be satisfactory. We concluded, however, to put in the cement, and we wish to say now that after five years experience, that we would have nothing else for driveways than cement. Our driveway may not be traveled as much as some streets, but the hauling we do over it is harder that the average hauling on streets. Our wagons are usually very heavily loaded, and being a driveway the wheels and horses would necessarily travel over the same surface repeatedly. The wear in five years on this driveway would not exceed 1-16 in. We have just converted the driveway into a retail room and in order to do this it was necessary to take the surface off the driveway, and it was done with the greatest difficulty. Our opinion is that this driveway would last for 50 years. Last fall we constructed Elm Place between our store and warehouse, and the hauling over this is very heavy, and there is probably more of it than there is over our driveway, because it is for the use of the public also. We can not see any visible signs of wear over any portion of it this far, and we believe that it is a street that will last a long time without any repairs. Furthermore it is easily kept clean, and although perfectly smooth we find no trouble in teaming over it. Horses do not slip on it and it is almost noiseless. There is no sound from wagons and very little from horses feet.

We consulted an expert on cement when this was built, and he remarked that a street constructed as we were making this one would last 100 years. We would have nothing else for our own use. We believe it to be the most economical from every point of view.

Yours truly,
Jones Hardware Co.

Richmond, Ind., Aug. 1, 1904.

SPECIFICATIONS FOR CEMENT WALKS, CURB AND GUTTER, AND ROADWAYS.

FOUNDATION "A."

Upon the sub-grade shall be placed clean, coarse gravel, 8 ins. in thickness after being thoroughly wet and rammed, and to a uniform depth of [4 to 6] ins. below the finished grade.

FOUNDATION "B."

Upon the sub-grade, prepared as shown by the cross section and as above specified, there will be placed a 6-in. layer of rubble, or field cobble stone, the refuse of quarries, old boulders taken from the old boulder curbing (if too large they shall be broken if used), or coarse gravel. Upon this layer shall be placed sufficient gravel to fill the interstices, and form a foundation with a total depth of 8 ins., after being leveled off and settled by flooding and ramming. Upon this bed will be placed a layer of good, clean gravel, 2 ins. in depth, to be properly spread, packed and smoothed, to receive the concrete curbing.

CONCRETE.

Upon the foundation place the concrete [4 to 6] ins. thick after being thoroughly rammed; it shall be uniformly 1 in. below the finished grade. The facing shall be placed in the templets forming the curb, backed up with concrete thoroughly rammed to place.

The concrete shall be composed of 1 part cement, 2 parts sand, and 4 parts gravel; the gravel can contain the sand, and 3 parts clean screened crushed lime stone. The proportioning of the cement, gravel and stone shall be done by placing a templet of the proper size upon a platform and placing therein the sand, gravel or stone by actual measurement in the proper quantities, leveling off the form with a straight edge; over the top evenly spread the cement in the proper proportions; remove the templet, turn the mass at least twice thoroughly, or until it is thoroughly mixed, add clean water from sprinkling can and thoroughly mix to make a concrete of such consistency that when deposited and rammed to place shall envelop every particle of sand with the cement, and every particle of gravel or stone with mortar. This result must be obtained to the entire satisfaction of the engineer.

The concrete shall be laid in blocks of the following dimensions: 6x7 ft. for 7-ft. walk; 6x6 ft. for 6-ft. walk; and 6x5 ft. for 5-ft. walk, with expansion joint separated by two pieces of three-ply tarred paper, at each 33 ft. of line, and intermediate joints with dry sand, as the engineer may direct.

WEARING SURFACE.

Before the concrete has set, deposit the wearing surface, which shall be 1 in. in thickness, composed of 1 part cement and 2 parts clean, coarse, washed sand, if the nature of the material require it; or 1 part cement, 1 part sand, and 1 part clean, crushed stone screenings. First mixed thoroughly in a dry state, then add sufficient clean water, and thoroughly mixed into a medium soft mortar. Deposit this upon the concrete and trowel down to insure a perfect contact, then level with a straight edge from the grade strips. When sufficiently hard, float and trowel to a smooth continuous surface. Avoid dusting the surface with dry cement.

The surface, except a marginal draft 2 ins. wide around each place and 5 ins. along curb line, shall be pitted with a brass roller acceptable to the engineer.

The wearing surface shall be cut in blocks the same size as the concrete base. As soon as the work has properly set, all templets to be removed and edges plastered to the full depth of templets, if required by the engineer.

All walks shall have a rise of ¼ in. per ft. from the curb to the lot line. Strips properly staked shall be set on both sides of the walk to keep it straight, being careful that the grade and fall are correct. Any walk not properly laid, must be taken up and relaid by the contractor.

CEMENT CURB, GUTTER AND CROSSWALKS.

The cement curb, gutter and crosswalks shall be constructed in place, under the direction of the engineer upon a bed of gravel 8 to 10 ins. in depth, after being flooded with water and completely rammed to an even surface. Upon the sub-grade will be laid Foundation A or B and, as shown by plan. The curb and gutter or crosswalks will be composed of concrete, formed by intimately mixing, dry, 1 part Portland cement, 2 parts coarse, clean sand, washed if necessary, 3½ parts of clean medium size gravel, and 5 parts of clean, screened lime stone, crushed to pass through a screen 1½ mesh, to which add sufficient clean water to form a concrete, that, when placed in the templets and thoroughly rammed, free mortar will appear on the surface. The ramming of the concrete in the forms shall be done with the proper tamping bars and other tools to insure a compact homogeneous mass, with full square corners. The stone shall be sprinkled before it is added to the mortar. The proportions given being intended to form a concrete in which every particle of sand shall be enveloped by cement, and every particle of gravel and stone enveloped by mortar, this result must be obtained to the satisfaction of the engineer. All exposed surfaces shall be covered with a finished coat 1 in. in thickness, composed of 1 part cement, 1 part of fine, clean stone screenings, and 1 part of clean, coarse sand.

The facing shall be placed in the templets forming the curb backed up with concrete and thoroughly rammed to place. The top facing of curb and gutter shall be thoroughly troweled to insure perfect contact. When sufficiently hard, float and trowel to a smooth true surface. The curb to be constructed with the top edge to the established grade of the street; the upper and lower face corner to be rounded to a radius of 1 in. The curb shall be 6 ins. thick at the top, and the gutter 8 ins. thick, and 28 ins. wide, and constructed in 7 ft. sections, alternately. When the intervening sections are constructed there shall be a strip of tarred paper placed in the joints, as the engineer may direct.

The proportioning of the cement, sand, stone and gravel shall be done by placing a templet of proper size upon a platform, and placing therein the cement, sand, stone and gravel in the proper quantities by actual measurement, leveling off the templets with a straight edge. Wrought iron protections will be built in all corners and places designated.

ROADWAY PAVEMENT.

The sub-grade will be thoroughly rolled, leveled and re-rolled until it is true to grade and cross-section of the finished roadway, and from 8 to 12 ins. below the surface of the street, as the case may be.

If found necessary for sub-drainage, upon the sub-grade, place [3 or 4] ins. of gravel, thoroughly wet and consolidated by rolling or ramming, or both.

Upon this gravel foundation will be placed a layer of concrete [4 to 5] ins. in thickness and finished to a true crown and grade, parallel to the finished street surface and [3 to 4] ins. below the same. This will constitute the foundation for the cement roadway.

When sufficiently strong to sustain the roadway paving, the surface of the concrete foundation will be covered with a coating of fine sand, raked off with a flat board rake, by hand, so as to remove all sand except that which may remain in low places and voids in the concrete foundation.

Upon this will be placed a layer of thin tar-paper (or other suitable paper) or material to act as a separating joint.

Upon this will be laid the concrete pavement [2 to 3] ins. thick, in sections the full width of the street and — feet in length, with expansion joint next the gutters and ends.

This roadway concrete will be composed of 1 part cement, 2 parts sand, 3 parts gravel and 3 parts crushed stone, mixed with water to form a rather wet mixture.

Upon this will be placed the wearing surface, 1 in. thick, composed of 1 part cement, 1 part clean, sharp sand, and 1 part clean stone or granite screenings, mixed with water to form a rather wet facing mixture.

The wearing surface will be deposited in two layers, ½ in. thick, the first to be thoroughly rammed to insure perfect contact; the second applied immediately after, and thoroughly troweled and worked over, and made to conform to the finished surface of the street by the use of the proper forms.

When sufficiently hard, the surface to be floated and steel troweled, and, lastly, raised with a cork float, and when finished must be true to grade and cross-section.

All concrete must be machine made, or thoroughly mixed by hand, as the engineer may direct.

CEMENT.

The cement shall be the best American Portland, or any other equally as good or better. No mixing of different cements will be allowed.

All cements must meet the following requirements:

Fineness.—Not less than 95% to pass a 50 mesh sieve, and not less than 85% to pass a 100 mesh sieve.

Time of Setting.—Initial set in not less than one hour.

Tensile of Strength.—One day, neat, 125 lbs. Seven days, neat, 400 lbs.

Constancy of Volume.—Cement shall not contain more than 3% of magnesia, and must remain perfectly firm and free from cracks after remaining in water for 28 days, and shall stand, without cracking, a temperature of 212 degrees Fahrenheit, after immersing in water for 24 hours.

All cements shall be kept in suitable houses for the purpose.

SAND.

The sand shall be clean, coarse river or bank sand, acceptable to the engineer.

WATER.

None but clean, clear water shall be used, which must be furnished by the contractor.

As soon as a section is finished, it shall be protected by placing muslin or canvas thereon, and in dry weather it must be kept moist for 5 days by thoroughly sprinkling.

A NEW STYLE OF SCRAPER EXCAVATOR.

The accompanying illustrations represent a new style of excavator, consisting of a scraper or bucket of special design, handled by a derrick mounted upon a car or a scow. This has been invented and patented by Mr. John W. Page, of Page & Shnable, engineers and contractors, Security Building, Chicago. The machines have already been used on important works, and are specially adapted for excavating in wet and soft material where it would be expensive or impracticable to carry a plant over the excavation.

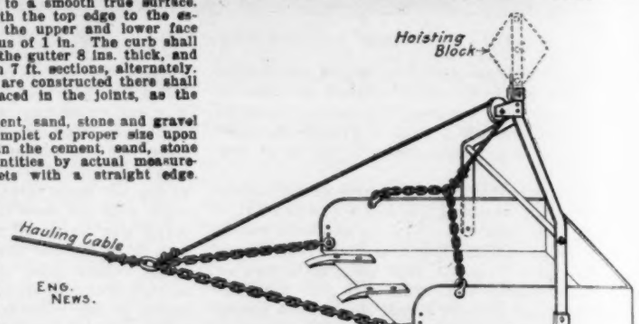


FIG. 1. SCRAPER OR BUCKET OF PAGE EXCAVATOR.

Fig. 1 shows the bucket and its attachments, and Fig. 2 shows the method of handling. It will be seen that the bucket has a bail to which the hoisting block is attached, which bail also carries a small pulley or sheave. The hauling cable ends in a ring from which chains run to the two front corners of the bucket, while a short length of cable runs from the ring to the pulley on the bail and down to a chain sling across the front

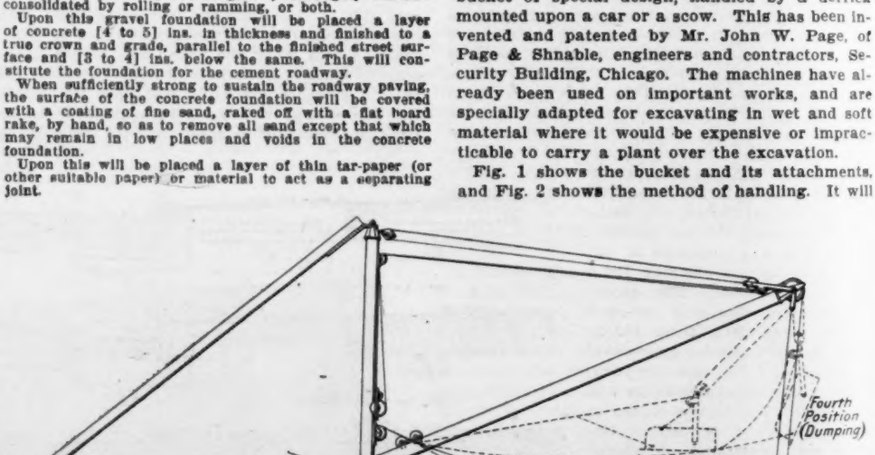


FIG. 2. DIAGRAM SHOWING METHOD OF LOADING AND DUMPING SCRAPER OF PAGE EXCAVATOR.

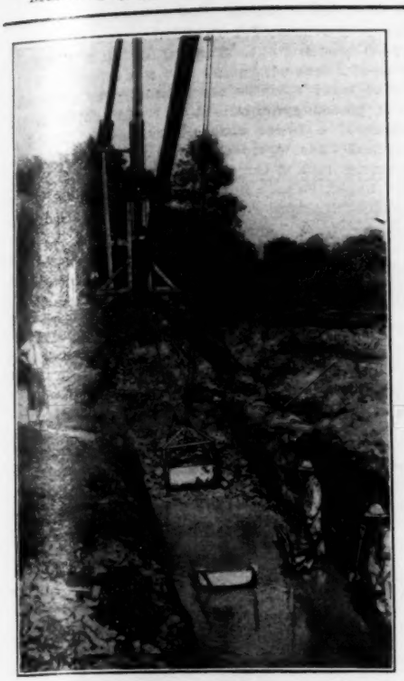


Fig. 3. Page Excavator at Work on the Hennepin Canal.

end of the bucket. The center of gravity of the load (and of the empty bucket) is in front of the bail, so that the bucket will dump automatically when the hauling cable is slackened. A plow may be used instead of the scraper where the material is hard, such as cemented gravel or hardpan.

The first machine was built in October, 1903, and used by Page & Shnable on their contract on the Hennepin Canal. The bucket was 5 ft. long, 3 ft. 6 ins. wide and 1 ft. 8 ins. deep, and the machine had a capacity of 350 to 400 cu. yds. per day. In Fig. 3, the scraper is shown at work on trenches 12 × 12 × 80 ft. for piers for an aqueduct carrying the canal across Green River. The material consisted of 6 ft. of earth and clay, 3 ft. of coal and 3 ft. of fireclay. The coal and fireclay were broken up by blasting. Fig. 4 shows the bucket fully loaded.

The trenches for foundations of retaining walls for the track elevation of the Pittsburg, Cincinnati, Chicago & St. Louis Ry. at Chicago, were excavated by a Page excavator, as shown in Fig. 5; and one was used by J. J. O'Heron & Co., of Chicago, for dredging out a cove in Green Lake, Wis., for improvements at the summer home of Mr. Victor Lawson, of Chicago. The material was deposited behind a concrete bulkhead wall.

Another of the machines is now being used by Mr. H. J. Petersen, who has a contract for furnishing black earth for the South Park Commission, Chicago. He is stripping a farm near Chicago Heights with a Page excavator having a bucket of 2 cu. yds. capacity, and loading gondola cars of 30 to 50 cu. yds. capacity in from 30 to 40 minutes. The method of operating is shown in Fig. 6. The excavator is mounted on rollers running on planks.

No switching engine is used, but the train is spotted by horse-power with block and tackle. After the excavator reaches the end of the loading track, it is shifted across to the other side of the track and returns, cutting another swath. Thus one placing of the track serves for the cutting of two swaths. The track is then shifted for the next two cuts, and so on.

For stripping work over comparatively level ground, for trench digging and for light dredging, this machine is one well worthy of every contractor's consideration. Many contractors already own derricks and hoisting engines which can be readily rigged for use with this novel excavating bucker or scraper. Moreover, a steam shovel is not well adapted to shallow cut work, due to the lack of a face to work to as well as to the frequency of the moves and the resulting large percentage of lost time. Here, however, is a type of excavator well adapted not only for light stripping but for deep trenching.

LONG SPANS IN TELEPHONE LINE WORK.*

By C. J. H. Woodbury,† M. Am. Soc. M. E.

Where telephone lines traverse mountainous districts or water courses it is frequently necessary to build spans of great length, using either one of the special bronzes or steel wire for the purpose.

The Connecticut River at Middletown, is crossed by wires having a span of 1,350 ft., suspended between a steel trussed tower 185 ft. high on the east side and a similar tower on the bluff on the west bank 85 ft. high. From Enfield to Windsor Locks the Connecticut is spanned by a suspension bridge consisting of two steel cables

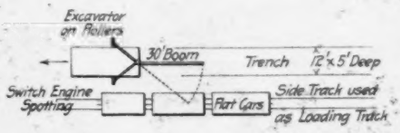


Fig. 5. Excavator Loading Cars on Panhandle Track Elevation.

1-in. in diameter and 955 ft. long, to which are fastened 2-in. by 3-in. joists 4 ft. 4 ins. long set 12 ins. on centers. On this bridge are laid four cables containing 100 pairs of wires. The towers are 45 ft. and 33 ft. high, respectively. The St. Francis River, near Madison, Ark., is crossed by a span of 1,000 ft., with the wires supported upon steel trussed towers 100 ft. in height, as it was necessary that the wires should be clear of steamers on the river, which has a varying level of 30 ft. between flood and drought. At the Raritan Canal crossing, near New Brunswick, N. J., a 60-ft. span is raised 112 ft. above the canal to avoid the shipping.

There are numerous long spans crossing ponds and rivers not used for navigation at which it is not necessary to erect such high towers or to draw the wires up to a small dip to avoid masts. Long spans are frequently strung in cases of emergency, as when the flood of June 2, 1903, carried away the bridge crossing the Kaw River at Kansas City, Mo., and also the wires attached to it; a span of wires 900 ft. in length was immediately suspended between high spars erected on either bank.

The Missouri River at the same city is crossed by a span of 1,500 ft., consisting of fifty No. 8 bronze wires suspended between steel trussed windmill towers 80 ft. in height. The Delaware River at Yardley, Pa., is crossed by an aerial span of 1,300 ft. in length with a dip of 10 ft.

In all instances, it is necessary to use great care in the anchorage of these long spans, for a rigid attachment would cause the wires to become broken when swayed by the wind. In some instances it has proved sufficient to carry the wires through semicircular grooves cut into a curved wood saddle upon each of the towers at the ends of the span, but the recurrence of breakages has been stopped in other cases only by attaching the saddles to springs which will yield to the impact resulting from swaying wires.

The very long spans constructed across the Mississippi, Hudson and Susquehanna Rivers have been advantageously replaced by submarine cables.

The most spectacular work in line construction has been done among the mountain ranges of the West. Lines have been built against the face of cliffs bordering deep canyons, where it was necessary to incline the poles so that the tops carrying the wires overhung the deep abyss, in order to avoid icicles and avalanches falling down the the precipice. In building telephone lines through this mountainous country, a couple of poles are slung like panniers on the sides of two or three mules tandem, and these sure-footed animals will carry them along the rough trails. The wire is wound in great lengths in connecting coils, which are placed on the sides of the saddles of a train of pack mules, which are thus connected on one side by wire from coil to coil, around the front of the foremost mule and thence back along the other side of the

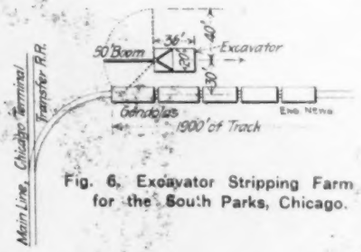


Fig. 6. Excavator Stripping Farm for the South Parks, Chicago.

train. By removing the last pair of coils and unreeling, and thence in turn to the next coil, the pair of wires for a metallic circuit can be laid down along a route.

The Mosquito Pass, near Leadville, Colo., was crossed at an elevation of 13,130 ft. by a line of poles which were set only 15 ft. apart at the more exposed places, but even this construction did not resist the storms of winter. Telephone lines were afterwards maintained through this Alpine exposure by an expedient as far out of the ordinary as the celebrated venture of Lord Timothy Dexter in sending warming-pans to the West Indies, and that was by replacing the line of poles by submarine cable carried to this elevated site in continuous coils, as in the case of wire transportation over the mountain trails upon a train of mules, and laid in trenches among the rocks to avoid any disturbances from avalanches. The rough valleys through which the routes pass are picturesque in summer, but in winter the snow accumulates to such depths that linemen attend to their duties on snow-shoes, reaching the lines on 25-ft. poles as if they were wire fences.

Among these mountains are ravines which can be crossed only by long spans, where the difficulties are increased by the inclination between the opposite ends of the span, which produces severe end thrusts at the points of support, which are built of three poles capped by crossbeams which must be held by the most secure guying.

A few of these spans will illustrate the conditions necessary to be overcome in order to extend the telephone to these isolated mountain towns, at all times difficult of access, and during the long winter a hermitage were it not for this telephone service. Imogene Basin, Colo., at an elevation of 13,700 ft., is crossed by a span of 950 ft. which inclines at an angle of 27°. Near Telluride and the Tomboy mines, ravines are crossed by similar long spans. A surveying party, arranging for the extension of some

*From a paper on "Telephone Line Engineering" read before the Franklin Institute, Philadelphia, Pa., on Jan. 12, 1905.

†Asst. Engr., American Telephone & Telegraph Co., 125 Milk St., Boston, Mass.

FIG. 4. SCRAPER LOADED; READY TO HOIST AND DUMP.

of these lines, found the snow to be 20 ft. deep in these basins in the middle of July, while avalanches had rolled down opposite sides of a valley, leaving a narrow pass bordered by snow and ice 100 ft. in height.

These lines running from the valleys up to great elevations on the mountains are charged with atmospheric electricity, particularly in winter, which is discharged to earth by bridging retardation coils across the lines and grounding the central part of the coils. The surveying party noted that these disruptive discharges of static electricity occurred about 16 times a second, producing a continuous sound which could be heard by one near to the wires. The mountain appeared to be enveloped by static electricity, the poles and the engineers' transit glowed with St. Elmo's fire, and an irritation was felt at the head, and the hair would fly up if the hat was removed. This electric envelope did not appear to extend to the ground, as one was entirely free from any sensations when lying down, but if, while in such a position, a hand was raised to about three feet above the ground, a sharp sputtering sound of static electrical discharges would occur.

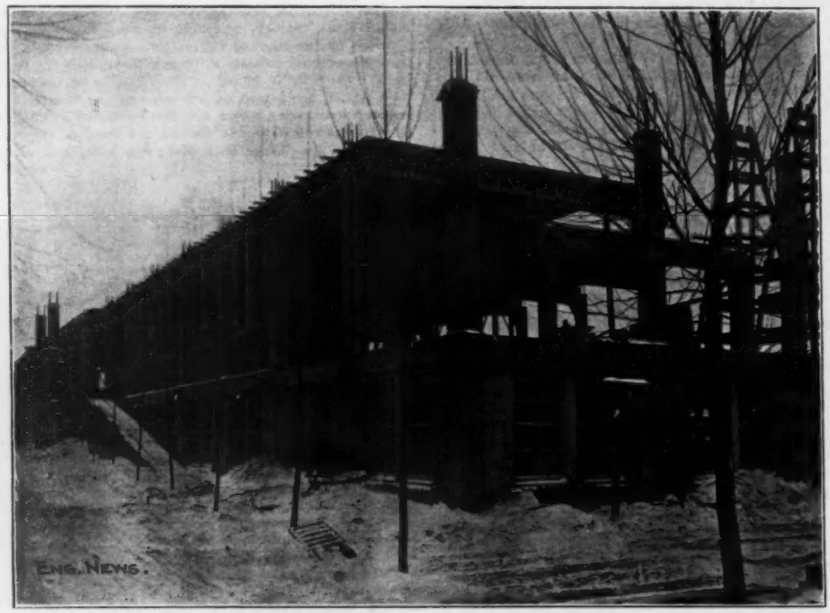


FIG. 1. GENERAL VIEW OF BUILDING SHOWING SOLID COLUMNS AND VISINTINI GIRDERS.

VISINTINI REINFORCED CONCRETE CONSTRUCTION, TEXTILE MACHINE WORKS, READING, PA.

By Leon S. Moisseiff,* Assoc. M. Am. Soc. C. E.

GENERAL DESCRIPTION.—The Textile Machine Works, of Reading, Pa., manufacturers of machinery for the textile industry, are at present completing the erection of a four-story building on their grounds at Reading intended for a machine shop for the general manufacture of their products. The machinery which will occupy the building is of the ordinary type, and could not be classified as heavy. The building is about 50 by 200 ft., and is constructed of reinforced concrete and brick; it contains no combustible material except the floor boards, the window frames and the like, and is thoroughly fireproof. Fig. 1 is the reproduction of a photograph of the building taken at the end of the last year, showing the first or basement floor and most of the second floor completed.

It will be seen from Fig. 1 and the following illustrations that the building is divided into a series of panels, with reinforced concrete columns at each panel point supporting open web floor beams, on which similar open web or lattice beams are laid, forming the floor. The walls consist of large size windows and dark red bricks, and the gray of the concrete, together with the red of the brick, produce quite a pleasing effect. The part of interest to engineers is the floor system of latticed reinforced concrete beams, which is used for the first time in the United States. It is known as the Visintini system of reinforced concrete beams, after its inventor, Franz Visintini, an architect of Zurich, Switzerland, and has been used quite extensively on the European continent during the last year. As seen from the photographs, the beams are latticed girders of the Warren or Pratt type, made of concrete reinforced where necessary by embedded steel rods. The saving in material and weight which can be obtained by the use of the open web beam is obvious to every engineer, and so are also the more definite determination of the stresses in the various parts and their correspondingly more correct design. But the main object of this system of construction is the manufacture of the small size beams under a shed on the grounds near the building in erection, where they can be made of good material under close supervision and inspection. They can be left to harden for a certain specified time, and be kept moist during this time to secure the best results. The beams may then be accepted on specified acceptance tests insuring sound beams when laid in place. No falsework is required for the erection of this floor, and the beams can be laid as are timber planks. This saves time and space, the building being, in fact, remarkably free from obstruction.

COLUMNS. — The building is 200 ft. long and 50 ft. 3 ins. wide, measured from centers of columns. It consists of three rows of columns, spaced longitudinally 12½ ft. c. to c., and transversely 25 ft. 1½ ins., or a total of 51 main columns. The wall panels between the outer columns are filled with double windows and brick walls. The outer columns are 15 by 15 ins. for the first story, and 12 by 15 ins. for the upper three stories; the central row of columns is 18 by 18 ins. for the first story and 15 by 15 ins. for the maining. Concrete footings, not reinforced, have been laid to a depth of 5 ft. 3 ins. below the floor level, varying from 6 by 6 ft. to 8 by 8 ft. On top of the footing a steel plate 13 by 13 ins. by ½-in. thick has been laid with a 3-in. hole in the center. Through this hole a 1¼-in. Thacher bar, 5 ft. long, passes, extending vertically half-way into the footing, and half-way into the column. The concrete in the footings was mixed in the proportions of 1 Portland cement to 3 sa[illegible] and 6 broken stone. The soil is clay, and a pr[illegible] sure of 2 tons per square foot was allowed on it.

The inner columns are reinforced by four st[illegible] rods placed symmetrically to the center in the edges of a 10-in. square, and are continued vertical lines up to the roof. They are 1¼ [illegible] diameter rods in the two lower stories, and 1 in. the upper. The outer columns are similarly [illegible] inforced by four rods, but these are spaced 9 [illegible] centers in the longitudinal axis of the buildi[illegible] and 6½ in. in the transverse. The sizes of th[illegible] rods are the same as in the inner colum[illegible] Sleeves of 1¼-in. pipes 6 ins. long are provided to connect the abutting ends of these rods. W[illegible] binders tie the four rods transversely every [illegible] apart. Reinforced concrete struts tie the colum[illegible] together at each floor in a longitudinal direction, and steel rods are embedded in the floor to tie them together transversely.

As shown on Figs. 1 and 2, especially in the latter, the floor beams rest on brackets projecting from the columns. Of course these brackets are properly designed and reinforced to perform their duty, but they also cause excentric stresses in the columns, which are provided in the outer columns by additional reinforcing rods.

TRANSVERSE GIRDERS.—Figs. 2 and 3 show the regular transverse girders. As seen, they are concrete trusses with verticals and diagonals. They are 24 ft. out to out, of a total depth of 2 ft. 0¾ ins. and 15 ins. wide. They are treated in their reinforcing as Pratt trusses with tension diagonals and compression verticals. The upper and lower chords are 4¾ ins. thick, and the diagonals and verticals 2½ ins. thick throughout. All diagonals have an inclination of 45°, and this with the distance of the upper and lower reinforcing rods, 20 ins. c. to c., determines the panel lengths. The reinforcing consists of three reinforcing trusses spaced 5-in. centers. The upper and lower rods are each 1⅝ ins. round bars, and the diagonals vary from ⅜-in. diameter as the least size near the center to ⅞-in. at the ends. The diagonal rods are bent at their ends to form eyes, through which the chord rods pass. Eighty-four such girders and thirty similar roof girders were required for the building.

FLOOR BEAMS.—The floors of the several stories, as well as the roof beams, consist of 6-in. Visintini latticed girders, as can be seen on Fig. 3. They are 12 ft. 1 in. long and 12 ins. wide, and are laid directly on top of the transverse girders like timber planks, leaving a space of 5 ins. between abutting ends, through which the transverse tie rods pass, and which is afterwards filled with concrete. The web is of the triangular or Warren type, with 45° inclination of the diagonals and of a constant thickness of ¾-in., the chords being each 1 in. thick. Each beam is 12 ins. wide, and is reinforced by three reinforcing trusses spaced 4½ ins. c. to c.; the upper reinforcing rods are ¼-in. diameter and the lower ⅜-in., with web members 1 in. by ⅛-in. in all tension diagonals, and six No. 20 sheet plates of same width to reinforce the compression diagonals during the handling of the green beams. The diagonals have holes punched near their ends, through which the

FIG. 4. VIEW OF MOLDING-ROOM FOR VISINTINI GIRDERS.

*Park Row Building, New York City.

chord rods are passed. About 2,900 such floor beams were required.

THE MAKING OF THE FLOOR BEAMS AND GIRDERS.—The making of the beams consists of two distinct operations: the manufacturing of the reinforcing trusses and the forming of the beams. Both of them have proved to be surprisingly simple. The diagonal bars are punched and cut to the right length by a punching machine in one operation, and another operation bends the ends of the bars 45°. They are then slid on the chord rods, which have previously been cut to the right lengths, and at their ends a vertical strap of the same stuff as the diagonals is put on and riveted by upsetting the ends of the chord rods by a hammer. This completes a reinforcing truss for the floor beams. It takes little time, and is done by boys in the machine shops of the works on the ground. About 8,700 such reinforcing trusses are required for this building.

FIG. 2. VIEW SHOWING VISINTINI GIRDERS AND COLUMN CONNECTIONS.

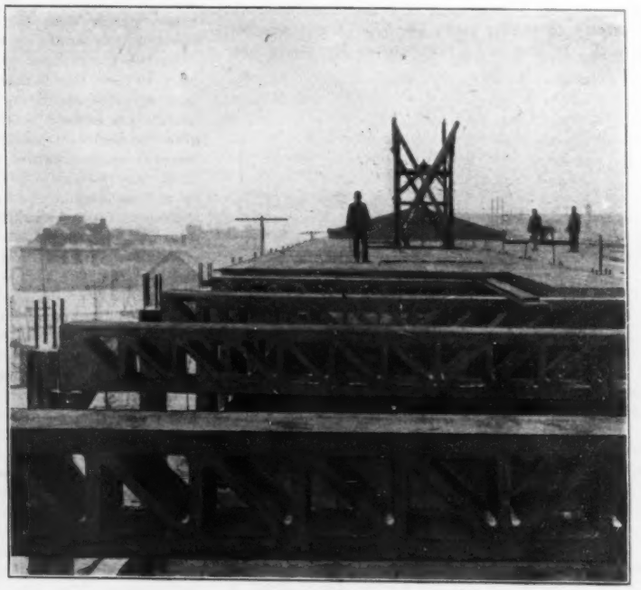


FIG. 3. VIEW SHOWING GIRDERS AND FLOORING OF VISINTINI BEAMS.

The molding of the beams is done in a building adjacent to the one under construction; the interior of this building, with the forms used, is shown on Fig. 4. In the left end of the photograph can be seen the bottom plank of the form, to the top of which triangular cast-iron plates are screwed, to act as spacers for the cores. The latter are triangular hollow cast-iron cylinders, properly rounded, and of same length as is the width of the beam. The walls of the forms are of 2-in. thick timber, and are held together by movable steel clamps. It will be noticed on the photograph that the forms are made for two beams each, side by side.

After the cast-iron cores are set over the bottom spacers, the walls of the forms are set up, and the concrete, which is mixed in a box to the right in a very plastic state, is carried in pails to the forms and poured into them. At the proper depths the reinforcing trusses are inserted, whereby the cores act as spacers for the diagonals, but care must be taken not to have any of the diagonal straps come too near to them. After the forms are filled, they are struck off level and clamped at the middle by an iron strap fitting into a projecting pin. The beams are then left to set. Quite a number of forms are on hand, and about a hundred of cores. As they have to be cleaned and greased before use, the cores are pulled out by a lever device three to four hours after the forming of the beam. The beams are left in the forms for two days or more, and can be handled at once by hooks and triangular wooden bars fitting in the open spaces, the weight of one of the floor beams being 480 lbs., or about 40 lbs. per square foot. The form boards and cores are then cleaned and greased, and are ready for fresh beams. The beams are carried by the men to the building elevator, on which they are placed and lifted to the floor in construction. A concrete, consisting of 1 of Atlas Portland cement, 1½ of a gritty, reddish brown sand, and 3½ of broken trap rock passed through a ring of 1⅝-in. diameter is used for the floor beams.

The transverse girders weigh each about 3 tons, and, wishing to have the floors completed without leaving out a panel, they were formed in the same manner as the small beams in forms alongside of their intended position at the corresponding floor level. They could have been made on the ground floor of the structure, and lifted in place, but this would have necessitated the leaving out of a floor panel in each floor.

The columns were, of course, molded in place in forms built for them in the usual way; 1-2-4 Portland cement concrete was used for the columns, and a pressure of 350 lbs. per sq. in. allowed on them.

TEST BEAMS.—Two of the 6-in. floor beams were tested to failure by loading them with pig iron, as shown in Fig. 5. The ultimate resistance of the beams gives an average of about 4,000 lbs. total load per 12-in. beam, or a load of 342 lbs. per sq. ft. outside of the weight of the beam itself.

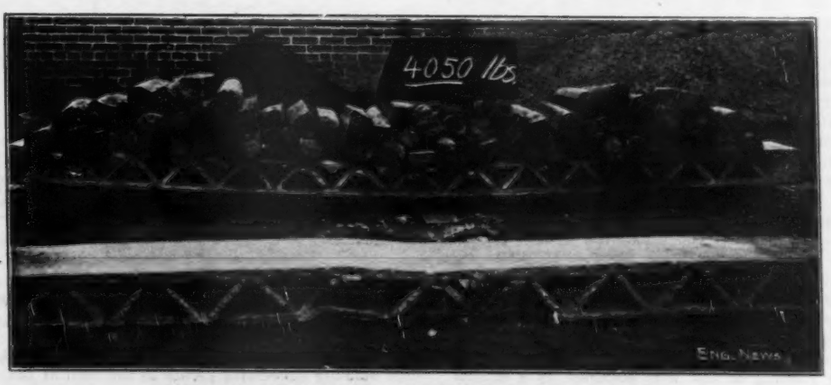


FIG. 5. VIEW OF TEST OF VISINTINI BEAM FOR FLOORING.

As the floor beams were designed for 75 lbs. per sq. ft. live load, the tests show a factor of safety of 4.5, figured according to the method now in vogue in the trade of considering the live load only, and of 3.3 according to the more correct way of considering both the live and dead loads. These test beams are shown in Fig. 5.

After completing and laying the floor beams, a maple floor will be laid on them. Timbers 2 by 3 ins. will be placed in each alternate panel space in the beams; on top of the beam, right over these timbers, 2 by 4-in. planks will be laid, and screwed together by bolts passing at the joints of the beams. This will tie together all beams, and make practically one unit of them, and will at the same time provide nailing strips for the floor boards. The 2-in. space will be filled with cinder concrete.

The building is being erected by the Textile Machine Works themselves, without subletting it to contractors. All men are employed by them directly, and they supply also all material. This procedure has proved to be very satisfactory, and credit is due to the management for obtaining the best material and for the intelligent handling of a system of construction used for the first time in this country.

The building has been designed by the Concrete-Steel Engineering Co., as consulting engineers, and this company controls the Visintini system in the United States.

AN AUTOMATIC SHIP LOG for continuously recording the speed of a ship, with an accuracy guaranteed to be within 2%, is now in use on a lake steamer, the "City of Erie," of the Cleveland & Buffalo Transportation Co. The log is wound up every 24 hours and a new record chart inserted. The position of the recording pen depends upon the position of a float in what is called the "speed pipe," which is a vertical pipe open at its lower end. As the speed of the vessel increases, water rises in the speed pipe, on the same principle that water rises in the pipe that takes water for a moving locomotive from a tank between the rails. This automatic log is made by the Nicholson Ship Log Co., 204 Superior St., Cleveland, Ohio.

A SPECIAL THEODOLITE FOR TUNNEL CROSS-SECTIONS AND GENERAL TACHYMETRY.

The nearly-completed Simplon tunnel, the world's longest tunnel, has been the occasion of producing a novel design of theodolite which facilitates a certain class of measurements, especially the cross-sectioning of tunnels and the like. The instrument, which has been patented, is the invention of Messrs. A. Mayer and E. Wiesmann, of St. Gallen, Switzerland, and has been used extensively in taking cross sections of the Simplon tunnel. It has some possibilities for other purposes than taking cross-sections, but this latter is its most important application. A description may be of interest to American surveyors and engineers, even though the instrument be found to have no advantages for use in this country.

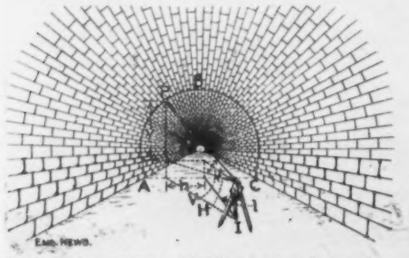


Fig. 1. Sketch Showing Method of Measuring Cross-Sections of Tunnels.

Suppose that in a tunnel it be desired to measure the cross-section at A B C, Fig. 1. Imagine an instrument set up at I, at a distance l from A B C. If the instrument is leveled and is oriented on a parallel to the tunnel center line (or preferably oriented on the center line), then a sight on any point, P, of the cross-section A B C will give horizontal and vertical angles H and V respectively. To compute the coordinates of P, the following relations are available:

$$h = l \tan H$$
$$v = l \sec H \tan V$$

The instrument in question is designed to give direct readings of the values of tan H, sec H, and tan V, so that, instead of reading off the angles in degrees and minutes, the observer reads and records the values ton H, sec H and tan V. Then, if l has been properly chosen as a multiple of 10 ft., the value of h can be immediately written down alongside the reading of tan H, and to get the value of v requires but a single multiplication. Where much cross-sectioning has to be done, a short table of the product sec H tan V can be prepared for the ranges of sec H and tan V likely to be met. This eliminates all computation and enables values of distance out (h) and elevation (= v + H. I.) to be obtained in the field as fast as the sights can be taken.

A drawing of the instrument, Fig. 2, indicates the means by which direct readings of tan H, sec H, and tan V are secured. The lower instrument-plate has a radial extension arm, A, in which is formed a tangential guiding groove. Above this is a radial arm, B, of the upper plate whose end is slotted with a radial slot. A two-part follower, F, engages the tangential guide-groove and the radial slot, this follower having its upper and lower halves pinned together by a central pivot-pin. The follower also bears the verniers for reading the scales on the upper and lower arms. The outer edge of the tangential groove (in the lower arm) bears a scale for tan H, while the radial edges of the slot in the upper arm bear scales for sec H. It is apparent that both these scales are of uniform value of division, since the motion of the follower is at all times in a tangent to the initial line.

The reading of tan V is obtained by a similar arrangement fitted in the place usually occupied by the vertical circle. There is a horizontal guide-groove in the standard C, and a follower-block G, carried by the vertical arm, D, attached to the horizontal axis of the instrument by clamp screws, slides in this groove. Only one set of scales is here provided, this being along the edges of the tangential groove, since no reading of sec V is required.

The other details of the instrument have nothing to do with its special purpose. It is to be observed that a double plate motion, such as is generally provided in engineers' transits, is required, in order to make it possible to orient the zero line of the horizontal scales on the assumed axis (center line of tunnel, or, in general, a normal to the cross section being measured). Moreover, the pintle carrying the instrument standards is rotatable on the upper plate, an arrangement which with the American type of transit construction would involve three horizontal plates.

In the instrument as built for use in the Simplon tunnel, the horizontal plates have a second pair of extension arms opposite the sec H tan H arms; this second set bears a scale graduated to give the deflection angles (for a unit chord of 10 meters) corresponding to various radii of curvature. As railway curves are generally designated by radius instead of "degree," in Europe, this attachment facilitates staking out curves. The instrument has the usual circular graduation on the plates. A vertical circle may be fitted, it is evident, on the side opposite the vertical angle slide.

Fig. 3 is a photographic view of an instrument of this design. The view does not show the extension arms of the horizontal plates, but the vertical tan-scale is clearly seen.

To mark the point sighted on, in a tunnel, any one of a number of devices may be used. If the tunnel is dark, the flame of a lamp sight held up close to the roof answers well. In other cases it is sufficient to hold a rod in contact with the tunnel wall at successive points of the cross section, sights being taken on the end of the rod.

The instrument is found very convenient for surveying quarries, where stadia measurements are frequently impossible owing to the inaccessibility of the walls. A vertical plane normal to the quarry wall then takes the place of the tunnel cross section. The instrument is set up at a known distance, l, from this vertical plane, the point where the plane is intersected by a perpendicular from the instrument being marked in the field. A rodman is stationed at the top of the quarry wall, in the plane of cross section in question. Provided with a plumb-bob at the end of a string, he lowers the bob down the quarry wall, thus defining successive points in the wall at that cross section. The observer, by sighting on the bob, obtains the horizontal and vertical coordinates of successive points of the wall in the way already noted for tunnel cross sections. By taking as many such wall sections as required, a complete survey of the quarry may be had.

A quite distinct application of this instrument may often be found useful. Suppose it be desired to obtain the distance, l, of the instrument from a point, C, Fig. 4. Mark two points A and B, lying in the vertical through C, and by means of a foot-rule or leveling-rod measure the height A B. Then, sighting on A and B successively, the readings tan V_1 and tan V_2 are taken from the instrument. Note that A C = l tan V_1, and B C = l tan V_2, so that A B = A C — B C = l (tan V_1 — tan V_2). Then the desired distance, l, is given by

$$l = \frac{A\,B}{\tan V_1 - \tan V_2}$$

Evidently the distance, A B, may be measured by the instrument-man when a leveling-rod is used by noting the rod-readings at A and B, the rod being held in one position for both readings. Where it is impracticable to handle a leveling rod, as in tunnels, A B may be measured by the rodman with a foot-rule.

The material for this description and the accompanying illustrations were obtained through the courtesy of the inventors of the instrument, especially Mr. E. Wiesmann, Chief Engineer of the Bodensee-Toggenburg Ry.

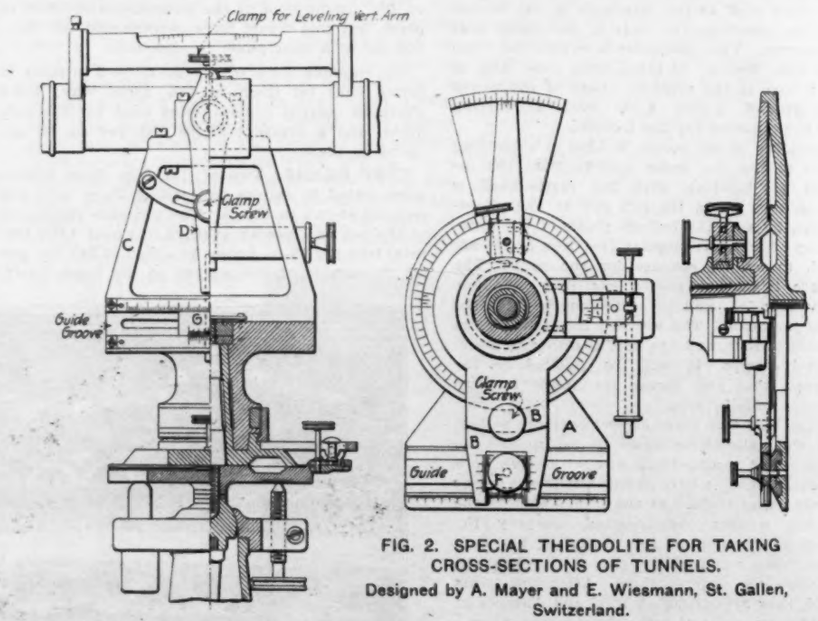


FIG. 2. SPECIAL THEODOLITE FOR TAKING CROSS-SECTIONS OF TUNNELS.
Designed by A. Mayer and E. Wiesmann, St. Gallen, Switzerland.

IGNITIONS AND EXPLOSIONS IN THE DISCHARGE PIPES AND RECEIVERS OF AIR COMPRESSORS.*

By Alex. M. Gow, M. E.†

Ignitions and explosions in the discharge pipes and receivers of air compressors are by no means uncommon. The increasing use of compressed air at higher and higher pressures, together with the general ignorance on the part of the men in charge of the machines, as to how and why such accidents occur, make it probable that they will continue to occur with greater frequency. For very obvious reasons the manufacturers say as little as possible about the subject to prospective buyers. It cannot be expected that the men in charge at the time of accident will make any report that will reflect upon themselves. So it happens that in but comparatively few cases of these accidents have the results of careful investigation been given to the public at large.

From an examination of about twenty accidents, of which more or less complete data have been gathered, a clear conception of the causes has been formed, from which may be drawn definite conclusions as to the means of prevention. In a number of the cases examined serious explosions have occurred, resulting in fire and death; in others, simply ignition, or burning out, with no other damage than that to pipe joints and gaskets. One case of a Bessemer blowing engine is reported where the pipes have been red hot on

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†Asst. Mech. Engineer, Oliver Mining Co., Duluth, Minn.

several occasions and been allowed to burn out. In another case the ignition so vitiated the air that was being sent into a mine that men were asphyxiated. The report upon a very serious explosion states that "the air in the discharge pipe first caught fire and then exploded," it having been observed before the explosion that the pipe was red hot.

It would be out of place in this discussion to mention the location of these accidents or the makes of the compressors. Such reference might be construed as reflecting on the maker or the

Fig. 3. View of Special Cross-Section Theodolite.

management. Furthermore, some of the information upon which this article is based was given with the understanding that no names or places should be mentioned.

These accidents are not confined to any one type of compressor, nor are they confined to cases where the terminal gage pressure is unusually high. It is in the discharge pipe and receiver that the trouble occurs, and in most cases the compressor escapes without injury. Rarely, if ever, does the explosion take place immediately in the cylinder. One case is reported where the cylinder head was blown off, killing the man who was examining the discharge valves, but even in this case the evidence does not prove that the explosion did not originate in the receiver. It is unfortunate that we have not the testimony of that man as to the condition those valves were in at the time, for, as will be shown later on, they were probably the immediate cause of the explosion.

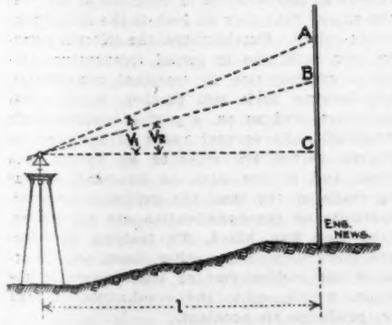


Fig. 4. Measuring Distances by Tangent Differences.

It is perfectly evident that just before such an accident there must be something to burn, in the discharge pipe or receiver, and a temperature sufficiently high to ignite it. Accumulation of combustible matter, together with a terminal temperature at the end of a compression stroke sufficient to start combustion, accounts for the cases of ignition; the presence of a gas or vapor, forming an explosive mixture with the air, with a temperature equal to the burning point of the vapor at the pressure, accounts for the cases of explosion. Where, as is reported in a few cases, ignition has preceded explosion, it is clear that in the first place there was a sufficient temperature to start combustion, and then there was driven off a gas or vapor, and this, mingling with the air in suitable proportions, formed an explosive mixture. We have, then, to inquire as to the origin and nature of the combustible matter and to the causes and conditions that tend to produce excessively high temperature.

ORIGIN AND NATURE OF THE COMBUSTIBLE MATTER.

Some lubrication of the air cylinder is necessary, and, as was to be expected, the combustible matter is found upon examination to be derived from the lubricant used together with dust from the air. It is around collieries that a majority of these accidents have occurred, but enough have occurred where the air was practically free from dust to make it clear that while dust, and especially coal dust, undoubtedly adds an element of danger, it is not the prime source. In the character and quantity of the lubricant used must be located the first cause of the trouble. The dust aggravates a condition first produced by the lubricant, and the lubricant assists the dust to deposit. One report from a colliery mentions that the walls of the receiver were coated an inch thick with a caked mass of dust and oil, which caught fire and burned out without producing an explosion. In another case, after the discharge pipe had been wrecked by an explosion, the deposit on the receiver walls was found to be 2 ins. thick. These deposits were no doubt the accumulation of years and they gave no trouble until, for some reason or other, there was a rise of terminal temperature. Then there was "trouble to burn."

It will not be argued that all the lubricant used in the air cylinder is deposited on the walls of the receiver, but some of it will be, and the more lubricant used the more will be deposited; and the greater the deposit of lubricant the greater chance for dust to adhere and produce in time the caked masses above referred to. Excess of lubrication, in addition to waste, means increased accumulation of combustible matter, increased lodgment of dust and increased danger of accident. It follows that just as little lubricant should be used as possible, and inasmuch as an air cylinder requires less oil than a cylinder of equal size using steam, the practice on the steam end should not be followed on the air end.

Two lubricants are in general use on air compressor cylinders, a mixture of soap and water and cylinder oil. Either can be made to do the work. The mixture of soap and water has inferior lubricating properties and must be used in quantities greatly in excess of those required of a proper lubricating oil. One case of explosion is reported where soap and water was used almost exclusively. A test of the deposit found in the receiver after the explosion showed that it readily ignited at 400° F. This deposit was 2 ins. thick. The mixture of soap and water was also tested in a laboratory. Upon being evaporated down to a "black, semi-solid mass" it ignited at 500° F. In addition to this soft-soap lubricant there had been used some oil having a burning point of about 400° F. The principal combustible ingredient in the deposit was coal dust. This case is sufficient to show that the use of soap and water is not a sure preventative of accident. In fact, it goes further and shows that soap and water may not be as good as oil, for the tests showed that it burned readily when dry, and inasmuch as more of it would have to be used than of oil, the deposit of dust would be correspondingly greater. Nevertheless, soap and water may be used to good advantage and provision should be made for its introduction into the cylinder when necessary.

While ignitions are bad enough and to be avoided if possible, explosions are more serious matters. Evidently they are due to the formation of a mixture of a combustible gas or vapor in suitable proportions with air, at a temperature sufficient to ignite. The percentage of gas or vapor required to make an explosive mixture is surprisingly small and in general, the heavier the gas or vapor, the smaller the percentage. This is well shown in the following table, the determinations being made by Dr. P. Eitner, of Carlsruhe:

Table Showing the Low Limit of Explosibility of Certain Gases and Vapors at Normal Temperature and Atmospheric Pressure.

	Per cent. by volume.
Hydrogen	8.5
Marsh Gas	6.3
Ethylene	3.4
Benzene vapor	1.4
Gasolene vapor	1.3
Benzol vapor	1.1

The percentage of combustible gas or vapor required to produce an explosive mixture decreases with the temperature of the mixture. For instance, at ordinary temperatures 16% of carbonic oxide marks the low limit of explosibility; 14.2% at 750° F.; 9.3% at 915° F.; 7.4% at 1,110° F. Furthermore, a mixture non-explosive at low pressure becomes explosive at higher pressure. If, then, there be a source from which a combustible gas or vapor may be derived, the conditions of pressure and temperature which obtain in the air receiver are favorable to the formation of an explosive mixture with the air. And as shown above, the amount required is very small indeed.

Now, combustible gases or vapors are evolved from all lubricating oils by heat. The lowest temperature at which they begin to come off is called the "flash point" of that oil. At a somewhat higher temperature the gas or vapor will ignite; this is called the "burning point." The flash point of kerosene is usually below 150° F. Ordinary lubricating oils flash at about 250° F. An average of determinations on 40 samples of heavy oils having average flash point of 360° F. gave average burning point of 398° F.; high flash test cylinder oils, from 500° F. to 560° F., gave burning points of 600° to 630° F. The vapors evolved from any of these oils, at the flash point, or the oils themselves, atomized or sprayed, would form an explosive mixture with the suitable percentage of air. From the above table it is evident that as low as 1% by volume would form such a mixture. If the oil were mixed with coal dust the temperature at which such a deposit would evolve a vapor would be the flash point of the oil. It follows that none but high flash test oil should be used in the cylinder.

Makers of cylinder oils claim that some oils have a greater tendency to deposit, or to "carbonize," as they express it, than others, and that the flash point is not necessarily a gage or measure of this "carbonizing" tendency. Lubricating oils are extremely complex chemical combinations of carbon and hydrogen, and it is not at all improbable that oils having the same flash test would deposit in different degree upon leaving the cylinder. Upon this point, however, no exact data, derived from experiment, have been obtained. The user of the compressor must make his own observations or take the oil manufacturer's word for it.

It is by no means uncommon for the engineer in charge of an air compressor to introduce through the inlet pipe a quantity of light oil, or even kerosene. This is a favorite and sometimes effective way of cleaning dirty discharge valves. Under such circumstances it is possible for an explosion to take place immediately in the cylinder, for the oil, being drawn in in the form of a fine spray or mist, and compressed with the air, produces just the conditions sought after in the cylinder of an oil engine. If an explosion did not occur it would be because the charge "missed fire," the terminal temperature of compression being below the ignition point. That the temperature of compression may rise to the ignition point, and that, too, in very few strokes of the compressor, will be shown later. If an explosion did not occur the light oil or kerosene, having a low flash point, being added to the accumulation of oil and dust already in the receiver, would serve to lower the temperature at which some time in the future a combustible vapor might be evolved. Such practice is simply tempting Providence; and Providence, at times, refuses to resist temptation. Among the cases examined, however, there is not one where the injection of light oil is given as the immediate cause of the accident. It is hardly to be expected that the engineer would report that his ignorance or stupidity caused the trouble. But the use of such oils for such pur-

pose can be fairly characterized as ignorance and stupidity. Considering how serious may be the results, stronger language would be warranted. If it is necessary to give the cylinder a heavy dose of lubricant on account of dirty valves, when the compressor cannot be shut down for cleaning, soap and water should be used, forced in by an oil pump, with which the cylinder should be equipped, in addition to the regular lubricator.

Special care should be given to the design of discharge valves and clearance spaces, that there may be no small pockets or recesses where oil may accumulate. This also applies to the piping from cylinder to receiver. Bends should be avoided as far as possible, for a change in direction of flow increases the tendency to deposit.

Despite all the care that may be taken as regards lubrication, there remains around collieries the dangers due to the accumulation of coal dust. It is well known that coal dust and air can make an explosive mixture, but it is hardly to be supposed that the air in the receiver could be sufficiently charged with dust to make trouble. Both anthracite and bituminous coals hold varying quantities of combustible gas, mostly marsh gas or "fire damp," in the occluded state, that is, as free gas, not chemically combined. No high temperature, such as is employed in destructive distillation in the manufacture of coal gas, is required to liberate this occluded gas. In a vacuum it may be driven off at the temperature of boiling water. At 300° F. it is readily evolved, with increasing evolution at higher temperatures. Such gas production would be entirely harmless unless a temperature of ignition were reached. But coal dust itself ignites at about 500° F. At this temperature, ignition followed by explosion is to be expected. The evidence in two cases of explosion indicates that this is exactly what occurred. The blame cannot be wholly placed upon the lubricant. It is responsible only in so far as it enabled the dust to accumulate.

Where a compressor is located near a coal breaker and the air is of necessity heavily dust laden, it would be wise to consider the installation of an air washer. The various methods of air washing cannot be discussed here. Suffice it to say that it need not be an expensive apparatus to operate or maintain, and that in summer time, with a suitable supply of relatively cool water, the reduction in temperature of the inlet air, with consequent increased capacity of the compressor and corresponding saving of power for a given weight of air compressed, would make the air washer an economical device, in addition to greatly reducing the chance of accident.

From the foregoing it would appear that under the best of conditions there is always the possibility of some combustible material accumulating in the discharge pipe and receiver, and under the worst conditions the certainty that the deposit will be excessive. Unless ignited it is harmless. What are the causes that lead to ignition?

TEMPERATURE IN DISCHARGE PIPE AND RECEIVER.

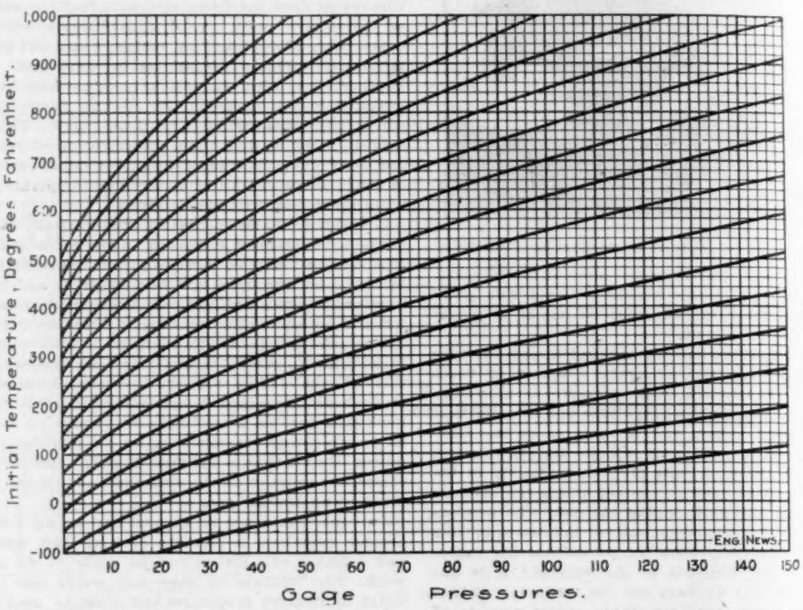
The temperature due to compression depends upon three factors: Initial temperature, before compression; pressure to which the air is compressed; efficiency of cooling devices. No account will be taken of the effect of moisture in the air, and all temperatures given are for dry air.

The initial temperature of a fresh charge of air within the cylinder is always above that of the supply from which it is drawn. It is to be regretted that no accurate means of determining the temperature immedately before compression has been devised. The inlet valves and cylinder walls are hot from the previous compression stroke, and in coming in contact with these heated surfaces the fresh charge is heated. How serious may be the effect of the rise in initial temperature due to this cause was pointed out by Mr. Julian Kennedy, in a paper on "Blowing Engines," presented before the World's Engineering Congress at Chicago. He said:

> This heating of the incoming air expands it and proportionately reduces the weight of air entering the cylinder at each stroke. I have observed this in the case of an engine which was so constructed as to cause the air to travel about 3 ins. over the hot metal in thin films 3-16-in. thick. Alongside of it was another engine of the same size and make except that valves were used that allowed the air to pass over about 1 in. of metal, the openings being of such size that each stream of air was 2 ins. in thickness. Careful and repeated tests of these engines, when both were in good order, showed that, while the indicator diagrams were practically the same, the one with the large valves would burn about 10% more coke in the furnaces, a result that could only be explained on the supposition that, in the case of the engine with the small air openings, the incoming air, in passing through the small and tortuous passages in the heads, was heated about 25°C. more than in the case of the other engine.

After the above testimony, further comment on the rise of initial temperature due to contact with hot metal surfaces is unnecessary.

Some rise of initial temperature is frequently attributed to the air in the clearance space, inasmuch as this air is at the temperature of discharge and becomes part of the next cylinder full to be compressed. When air expands without doing work, the slight drop in temperature, known as the Joule-Thomson effect, is insignificant. If, however, it expands against resistance, doing work, its temperature falls, and the fall is proportional to the work done. With mechanically-operated inlet valves, set to open the instant the return stroke started, the clearance air would expand wihout doing work and would serve to raise the initial temperature of the incoming charge. But this would be inexcusably bad valve setting.



CURVES SHOWING RISE OF TEMPERATURE DUE TO ADIABATIC COMPRESSION OF DRY AIR.
(Initial temperatures of curves are taken 40 degrees apart, beginning at 100 degrees below zero.)

With poppet valves, opened by a slight vacuum within the cylinder, the clearance air expands against the piston and does work, and the expansion being very rapid it is presumably adiabatic. Consequently, there is a fall of temperature. In fact, owing to the absorption of some heat while within the clearance space, it is possible that the clearance air, expanding, reaches a lower temperature than that of the charge from which it was derived. In well-designed compressors clearance space is reduced to a minimum, for the sake of capacity, so that, even if there were no drop in temperature of clearance air, the rise of initial temperature due to this cause cannot be serious.

The place from which the air is drawn may have a very important bearing on initial temperature. The engine room is, to be sure, better than the boiler room, as the source of supply, but that is about all that can be said in favor of it. The inlet should be at the coolest and cleanest place available. A difference of 50° between the engine room and the outside air means more than a difference of 50° in terminal temperature, as well as a loss of about 10% in capacity for the same amount of power expended. The report on one explosion makes the recommendation that the air be drawn from an air shaft, cooled with water sprays. Such an arrangement might be adapted to wash the air at the same time.

The effect of leaking discharge valves upon initial temperature and consequently upon the temperature after compression, may be very serious indeed. Suppose an extreme case, where the amount of leakage is just sufficient to maintain atmospheric pressure within the cylinder so that no fresh air enters. The initial temperature is now nearly the same as the terminal temperature of the previous charge, for the compressed air, in leaking back, has done no work upon the piston, and consequently has not dropped any in temperature. The hot air now receives a second compression, and the terminal temperature, reached by starting from an initial temperature due to the previous stroke, may easily reach the point of ignition of the combustible matter. If the initial temperature were 60° F. and terminal pressure 40 lbs., the terminal temperature, with no cooling, would be 300° F. If this air at 300° F. leaks back and compression starts from that temperature, the temperature of discharge becomes 650° F. With a discharge valve stuck open it is plain that in one stroke of the compressor a temperature might be reached sufficient to ignite the best grade of high flash cylinder oil.

It would be an exceptional case, however, in which the discharge valves leaked so badly that there was no introduction of fresh air at all. Yet to the extent that they do leak is the initial temperature raised. Furthermore, the effect is cumulative, for each rise in initial temperature produces a greater rise in terminal temperature, which, leaking back still further, raises initial temperature, and so on, a sort of endless chain arrangement. In several cases of accident the discharge valves are reported as having been leaking, and in one case an examination was being made at the time the explosion occurred. The results of the examination are not known, for the man was killed. To leaking discharge valves, more than to any other cause, may be attributed the sudden rise of temperature in the receiver, which, with the combustible deposit there, produces an accident.

It is well to note that a given rise in initial temperature produces a greater rise in terminal temperature. The accompanying curves show the rise of temperature of dry air, adiabatically compressed, from various initial temperatures to all gage pressures up to 150 lbs. It will be observed that a difference of 40° initial temperature, from 60° F. to 100° F., produces a difference of 72° terminal temperature, at 100 lbs. pressure. This tends further to increase the cumulative effect above referred to as due to leaking discharge valves, for a rise of 1° at the beginning of a stroke involves a rise of nearly 2° at the end when compressing to 100 lbs., single stage.

It will be observed that with single stage com-

pression from 60° F. initial to 80 lbs., without cooling, a temperature of 430° F. is attained. This is a lower initial temperature than generally obtained; yet from what has gone before it is clear that such a terminal temperature is beyond the danger line, even when valves are tight.

The curves also show the rise of temperature with pressure, and make it obvious that, other things being equal, the higher the pressure the greater the likelihood of dangerously high temperatures in the receiver. As a question of fact, there is greater liability to accident at low pressures than at high. If a plant were to be installed to deliver air at 1,000 lbs. pressure, stage compression would be used, the questions of inter and after-cooling very carefully considered, and all precautions taken in design and operation to avoid high temperatures. But in the design, installation and operation of a single stage compressor, working, say, to 40 lbs., such precautions are not taken. The plant does not command respect. Yet, as shown above, in a few strokes, with a sticking discharge valve, a temperature may be attained sufficient to cause everybody within reach to have a wholesome respect for such a magazine of explosive energy as a receiver may become.

From the foregoing it would appear that all precautions having been taken, we must look for safety from accident to the cooling devices employed to keep down terminal temperatures. Despite all the care that can be taken, some combustible material is sure to accumulate in the receiver. Give it time enough and it will get there. It cannot be expected that discharge valves will forever and always remain tight. Reliance must be placed upon water cooling.

The former practice of injecting water into the air cylinder has been abandoned on modern machines for mechanical reasons. Water jacketing of heads and cylinders on large machines is customary, but such jacketing is entirely insufficient to insure proper cooling. The area of the cool surfaces is so small relative to the volume of air compressed and the time of contact is so short, that the cooling effect is small. But water jacketing is most efficient in keeping down the temperature of the metal in contact with the fresh charge, thus keeping down initial temperature. This, and the aid rendered lubrication by keeping cylinder walls comparatively cool, are the chief services performed by the water jackets. On large machines they cannot be depended upon to absorb the heat of compression. There is too much heat for the time and surface.

Compression by stages, with inter-cooling, with provision for after-cooling in an emergency, are the surest means by which to avoid dangerously high temperatures in the receiver. The curves show the reduction in terminal temperature that may be attained by inter-cooling to any temperature between stages, and inasmuch as for adiabatic compression, the rise of temperature is proportional to work expended, they also show to what pressure each cylinder should operate in order that each shall do an equal amount of work. Knowing the weight of air compressed per stroke and its specific heat, the curves also give the necessary data from which to calculate the British thermal units to be absorbed by the inter-cooler.

The economies that may be effected by stage compression are well known, but it must be remembered that the economy depends upon the efficiency of the inter-cooler. Without inter-cooling, stage compression effects no economy over single stage. That the inter-cooler may be efficient, it must have ample cooling surface, and it may be remarked here that for the sake of first cost, to cut down the size of the inter-cooler, as is the practice of some manufacturers, is the poorest kind of economy. As well expect to get boiler economy by cutting down heating surface. Economy in both cases depends upon the transference of heat to water, through metal. The amount transferred, other things being equal, depends upon the surfaces in contact.

The after-cooler may be similar in construction to the inter-cooler, or, if water at sufficient pressure is available, it may be a simple water spray so arranged, like a sprinkler head, to throw a fine mist or spray into the discharge pipe. This spray need only be used in an emergency when the temperature in the discharge pipe has risen to the danger point. A steam jet will answer the same purpose, but owing to the latent heat of evaporation, a given weight of water will have greater heat absorptive power than the same weight of steam. Ample provision must be made upon the receiver to drain off this cooling water, but the receiver should have an ample drain anyhow, and be large enough and so designed as to act as a separator. Only in very exceptional cases would the addition of a cooling spray to the discharge pipe increase the moisture content in the air from the receiver. Usually the air is already at the point of saturation. It cannot be any wetter than it is. This is proven by the fact that water generally accumulates in the receiver. The air is already at the "dew point" and cannot hold any more water at the temperature and pressure. In fact, it is entirely possible to cool the air in the receiver by the addition of water, so that the moisture content will be reduced and the air at the drills or mining machines will be actually dryer than if no water had been added. With a receiver built upon the lines of a steam separator, this result could be readily accomplished, the dangers from explosion practically eliminated, and the troubles due to "freezing up" reduced to a minimum.

Thus we reach the somewhat curious conclusion that the troubles due to heat, namely, ignitions, and the troubles due to cold, namely, "freezing up," may both be greatly alleviated by the same remedy, namely, adequate after-cooling.

If the after-cooling is to be done by a spray and only used when required, it is necessary to install thermometers on discharge pipes, that the temperatures may be observed. Recording thermometers would be preferable for such purposes, but mercury thermometers, with large graduations, reading up to 1,000° F., are not expensive, and would serve the purpose. They should be capable of being read from a distance, and the engineer should watch them as he would a steam gage.

That the liability to ignition and explosion may be reduced to a minimum, the foregoing considerations warrant the following conclusions relative to the design, installation and operation of air compressors:

DESIGN OF COMPRESSORS.—(1) Clearance space should be reduced to a minimum. (2) Ingoing air should traverse as small a surface of hot metal as possible. (3) Discharge valves and passageways should contain no pockets or recesses for the accumulation of oil. (4) Cylinders and heads shoud be water jacketed; in some cases piston water cooling may be resorted to. (5) Stage compression, with adequate inter-cooling, should be employed wherever final pressure and first cost of installation will warrant. (6) Discharge valves must be easy of access for cleaning and examination. There must be no excuse for dirty or leaky valves.

INSTALLATION OF COMPRESSOR.—(1) Air should be drawn from the coolest and cleanest place possible, and never from the engine room. Engine room air is never cool nor clean, and an open intake is a constant invitation to squirt oil in from a can. (2) Around collieries it would be well to consider the washing of the air. (3) A thermometer, preferably recording, should be placed on the discharge pipe. (4) Provision for after-cooling should be made; a water spray will answer, to be used when the thermometer indicates the necessity. (5) The receiver should be provided with a man head for cleaning, and a drain easy of access and ample in size. (6) Automatic sight feed lubricators should be depended upon for regular lubrication, but in addition an oil pump may be installed for the introduction of soap and water in case of necessity.

OPERATION OF THE COMPRESSOR.—(1) High-flash test cylinder oil alone should be used for regular lubrication. Under no circumstances must kerosene or light oil be introduced. If an extra heavy dose of lubricant is required, give it soap and water through the oil pump. (2) Discharge valves must be kept tight, and to this end the use of the steam engine indicator is advised. The cards may not tell much about the condition of the valves, but one of the greatest values of the indicator is the moral effect upon the engineer. (3) Discharge valves should be cleaned from dust and oil and frequent examinations made to see if they need it. (4) Accumulation of water and oil must be blown from the receiver and an internal examination made at stated intervals. (5) The thermometer should be watched like a steam gage. Before it reaches 400° F. get busy. This is the danger limit. Put on the after-cooling spray, examine all water supply pipes and the discharge valves. (6) After the designer has done all in his power to make a perfect machine, and after the purchaser has taken all reasonable precautions to install it with every safeguard against accident, the responsibility must rest on the engineer in charge. He should be thoroughly instructed as to the possibility of explosion, the dangers attendant upon the use of any but the prescribed oil, and the effect of leaking discharge valves. He should be instructed in the use of the steam engine indicator and required to submit cards at stated intervals. He should record in the engine room log the daily condition of the machines under his charge. He should be given a wholesome respect for an air compressor, with imperative instructions to keep it clean, inside as well as out.

It may be objected that some expense is involved in following all the above recommendations and suggestions. In the preparation of this paper about twenty different concerns have been found that have learned from experience that explosions and ignitions are expensive. Very many more could give the same testimony.

SPECIFICATIONS FOR AN AIR COMPRESSOR.

Very complete specifications for the machinery required for an air-lift pumping plant for the Borough of Spring Lake, N. J., were recently filed at this office. Included in the specifications were several pages relating to the air compressor to be furnished for the work. It is rare indeed to see purchasers of air compressors specify what they require, and still more rare to see specifications for an air compressor in print. We therefore print these specifications in full as follows:

Air compressor to be of Cross Compound steam and duplex air, and shall deliver 526 cu. ft. of free air per minute at a pressure of 100 lbs. per sq. in. The compressor shall be self contained and counterbalanced, and the weight as uniformly distributed as possible.

The main frame shall be in one casting absolutely free from cold shuts, blow holes, shrinkage cracks, etc., and shall be well stiffened with internal ribs if of box type, and if of Tangye type, it must be well stiffened in the bottom or box section. The ends of frame to which cylinders bolt shall be bored and faced at the same setting to insure perfect alinement. If the guides are bored, then same must be machined at the time of facing to insure correct alinement.

The main bearings shall be cast solid with frame, and shall be bored and faced for removable phosphor-bronze bushings or other approved design. If bushings are used, these bushings shall be made in three sections, and must have adjustment in two directions to maintain correct alinement. If bushings are not used, the brasses must have approved method of alinement and adjustment. If boxes are fitted with soft metal, the metal shall be spotted and be of A 1 quality, and scraped to a perfect surface.

The cylinders shall be made of a mixture of charcoal iron and selected scrap, and shall be hard, close grained, free from blow holes and designed to withstand a working pressure of 160 lbs. per sq. in. after being rebored. They shall be bored true and have smooth finish.

The steam valves shall be of approved design, accurately fitted and adjusted for maximum economy. Should cut-off valves be adopted, they shall be of the Meyer type, adjustable, and shall be perfect in fit and surfaces scraped to insure perfect bearing. Drawings of valve gear shall be submitted for approval of engineer.

The air cylinders shall be made of a mixture of charcoal iron and selected scrap, and shall be of sufficient thickness to permit reboring. The air cylinders and heads shall be thoroughly water jacketed. These cylinders shall be free from blow holes and accurately bored and faced, and shall be of exact dimensions and interchangeable in every particular. The limit of variation of bore shall not exceed ± 0.002-in.

The air heads shall be hooded and the intake so arranged that free air can be applied from outside the compressor room or from any point where clean, cool air is obtainable. The contractors shall submit plans of air cylinder for approval of engineer.

The inlet valve shall be of approved design, and shall be proportioned to insure full intake of free air at each stroke of piston. The inlet ports shall be proportioned to give an unrestricted admission at maximum speed, and valves so placed that the clearance losses are a minimum, and clearance shall not exceed 2%, unless from other considerations (in the opinion of engineer) this can without involving an appreciable loss, be exceeded. The valves shall be so arranged that they can be removed without disturbing other parts of compressor. The valves shall be of poppet type, turned out of solid tool steel, and shall be as light as practicable. They shall be so guided that they cannot easily get out of line, with respect to their seats. There shall be provided removable seats of steel, or other approved metal, so arranged as to be easily removed when necessary. The contractor shall submit

plans of above for approval of engineer, and shall submit specifications for approval.

The balance wheel shall be made of cast iron of heavy pattern to insure smooth running. Wheel shall be securely fitted to shaft. It shall have a broad face. The face as well as the side of rim shall be trued up. The castings shall be free from imperfections and so designed that no large fillets or unequal expansions can take place which could put up heavy shrinking strains. The wheel shall be tested for soundness and every test known to determine imperfections shall be applied.

The main shaft shall be of open-hearth steel, and shall conform to the specifications of materials forming part of these specifications. Cranks shall be of disk pattern made of strong cast iron and accurately counterbalanced. They shall be forced on shaft by hydraulic pressure and keyed. The fact and side and bosses shall be machined and bright finished.

The crank pins shall be of material hereinafter specified, and shall be carefully hardened and ground, and so fitted that exact parallelism between pins and shaft shall be secured.

The cross head shall be of the slipper type, or other approved type made of charcoal iron, or steel casting. The cross head shall be provided with composition slippers of large surface, and shall be adjustable from opening in frame. They shall be so fitted as to insure an absolute uniform bearing, preventing any angular movement in a vertical plane. The slippers shall be of composition as specified.

There shall be provided ample bearing for wrist pin and it shall be a perfect fit in bearings. The wrist pin shall be hardened and ground.

The piston rod end shall be of approved design and sketches showing method of securing said rod to cross head submitted for approval.

Both steam and air pistons shall be of the solid type, or other approved type, having broad faces, fitted with snap rings of good quality iron. After turning, the rings shall be cut and clamped smaller, and in this condition turned to size of cylinder. The rings shall have a perfect bearing over the surface of cylinder, and shall be turned as above to insure this condition. A thorough examination shall be made after machine has been run for a short time, to determine the condition of cylinder. The piston rod shall be of steel (of the composition specified hereinafter) turned true and polished.

They shall be forced into piston and secured by steel nut. There shall be provided a shoulder on piston rod to prevent wedging action. The steel nut on end of rod shall be secured by approved method.

There shall be provided an automatic governor which shall regulate the speed of compressor within proper limits as set forth hereinafter.

All bearings shall be liberally proportioned and carefully fitted.

All parts of compressor shall be easily accessible for inspection, adjustment or repair.

All work shall be strictly first class in every detail, and materials of construction shall be the best in the market, and shall follow the requirements set forth hereinafter as near as can be purchased in open market. All castings shall be thoroughly cleaned and all fins removed.

If compressor is furnished with base plate, said plate shall be free from imperfections which would have a tendency to impair its strength and appearance. It shall be well ribbed and otherwise well designed.

The compressor shall be furnished with grease cups in place of oil cups. These cups shall be of the compression type, nickel-plated. There shall be provided with machine the following: Two 1-quart Detroit lubricators. Grease cups for rods, cross heads, main bearing and any other points where same are usually fitted. Cylinders, both steam and air, shall be provided with indicator pipes and three-way cock and valves. Drip pipes and valves. Steam pipe up to throttle valve. One throttle valve, so connected that the engineer can operate it from outside of engine. The hand wheel to be placed outside, and not on the inside as is usual.

The steam cylinders shall be covered with non-conducting material, and neatly lagged, with either wood or polished iron, which ever is approved by engineer.

The compressor shall be first class in workmanship throughout and shall be amply large for the work to be performed, and shall be capable of standing an overload of 25% indefinitely.

All bright parts will be neatly finished and all trimmings to be nickel-plated as before mentioned.

All bolts, nuts, etc., must comply with the requirements set forth hereinafter.

There shall be provided an air tank of proper size for this compressor, made of steel of 60,000 lbs. tensile strength. Longitudinal seams double riveted, rivets staggered. Girth seams single riveted. Tank shall be provided with necessary attachments, and shall also be provided with safety valve. The test for tank shall be the same as set forth for boiler, and it shall be of first class workmanship. All rivets must fill the holes, and holes shall be punched ¼-in. smaller and drilled after plates have been rolled and brought to proper position. No drifting will be allowed. No sharp caliking will be permitted, and the work throughout must be of the very best.

The steam cylinders and air cylinders shall be provided with metallic packing of most approved type, and must be of a grade and type equal to France Metallic Packing. If valve stems are 1 in. in diameter, then there shall be provided metallic packing for these also. There shall be submitted for approval samples of metallic packing, which, in the judgment of the contractor, he prefers to use. These shall be approved by engineer before same shall be used.

A PORTABLE ELEVATOR FOR LOADING FROM STOCK PILES OF STONE OR SAND.

The accompanying photographs, Figs. 1 and 2, show a novel elevator designed to be used for loading wagons or cars with stone, gravel or sand from stock piles. The elevator shown in the illustration was built for the Buffalo Cement Co., and has been used for loading broken stone into wagons. Two men, at the foot of the elevator, feed the stone from the stock pile, and these two men with the driver comprise the full force required to operate the machine, which is driven by a 2-HP. electric motor. A wagon is loaded in 8 mins., although the record time is said to be 4 mins.

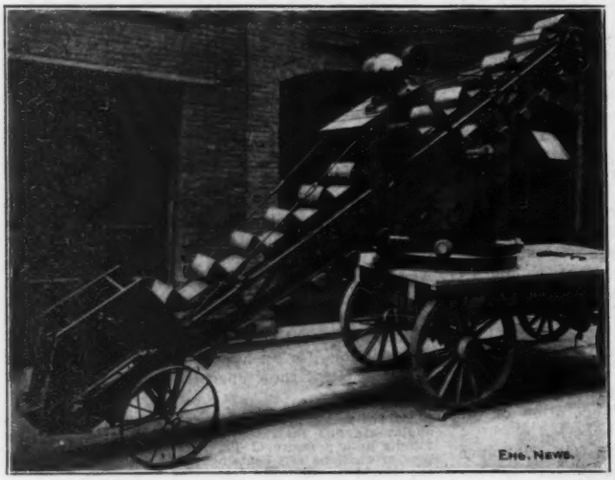


FIG. 1. A PORTABLE ELEVATOR FOR LOADING CRUSHED STONE.

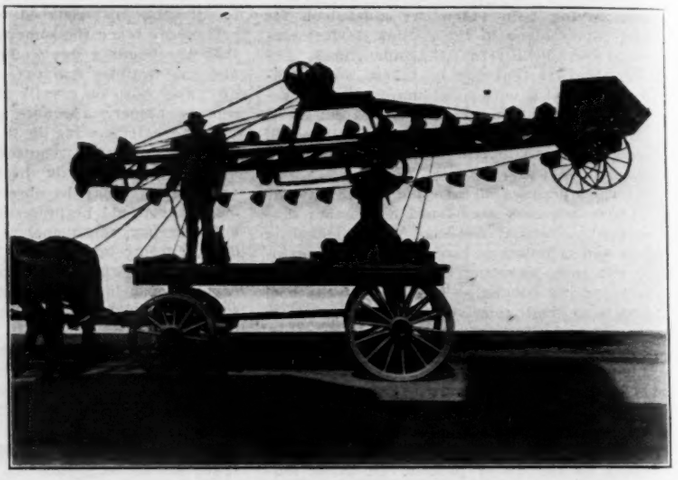


FIG 2. PORTABLE ELEVATOR READY FOR TRANSPORTATION.

A machine of this same general pattern was built to be run by a 5-HP. gasoline engine. During the past season it has loaded 1,500 car loads of sand from stock piles. One man runs the gasoline engine, and two men with a team of horses and a scraper deliver the sand to the foot of the elevator. The freight cars are moved for the trimming, so that there is no labor charge for that item.

There have been a number of wagon-loading devices invented for use in connection with wheel and drag scrapers, but, almost without exception, they have not been readily moved from place to place. In handling earth from light cuts this lack of portability is a serious objection to any mechanical wagon loader. It would seem that with a gasoline engine equipment, such as the one just described for loading sand, it would be possible to load wagons with any kind of earth that can be handled with scrapers, and at a low cost. Certainly there are many sand and gravel pits where such a machine would effect a considerable saving in the cost of loading.

This elevator is made by the Geo. F. Wescott Co., of Buffalo, N. Y.

THE COST OF FEEDING HORSES AND COST OF HAULING.

The cost of feeding 25 working horses for a period of 12 months is given in the last annual report of the Chief of Engineers, U. S. A. The horses were kept steadily at work hauling materials for constructing roads near San Francisco, Cal. The following was the cost per horse per day:

28 lbs. wheat hay, at $15.50 per ton	$0.2
12 " rolled barley, at $24.10 per ton	0.
1½ " oats, at $27.40 per ton	0.
¼ " bran, at $21.20 per ton	0.
1½ " straw bedding, at $13.80 per ton	0.
Wages of stableman ($775 for 12 mos.) and hauling forage ($281 for 12 mos.)	0.
Total per horse per day	$0.

The above shows a consumption of 41.7 lbs. feed per horse per day, which seems large, but not excessive for heavy draft horses worked daily. A conservative estimate of the food waste is 5%.

Four-horse teams averaged about 16½ miles traveled per day over fair macadam roads, the loads, grades, etc., being shown in the following table:

	Case I.	Case II.
Loads per day	14	7
Length of lead	3,000 ft.	6,200 ft.
Level	2,400 "	2,400 "
On 5% grade	600 "	3,800 "
Gross load	3.65 tons.	3.15 tons.
Tare	0.65 "	0.65 "
Net load	3.00 "	2.50 "
Tractive force on level	235.5 lbs.	220.5 lbs.
Tractive force on 5% grade	646.0 "	578.0 "
Duty per day, ft.-lbs.	16,000,000	21,000,000

In each of these two cases the roadway was fair macadam, and the tractive force per ton (2,000 lbs.) was taken at 70 lbs. (which, it is stated, is probably too low) on the level, and 112 lbs. per ton on 5% grades, the 12 lbs. being added for the weight of the horses. The calculations are based on a dry roadway; this is true for Case II. but not for Case I., for part of the hauling in Case I. was during the winter, when the tractive resistance was probably 25% to 33% greater.

Trautwine (p. 685) says that a horse, traveling on a level roadway at 2½ miles per hour, should do 13,200,000 ft.-lbs. in a 10-hour day. The performances above cited will be seen to be equal to or greater than this average, when the proportion of heavy uphill hauling is considered in Case II., and when it is considered that the teams traveled loaded half the time and unloaded the other half, and were idle part of the time, during the loading. The report says:

> It has been frequently expressed as an axiom that the cost of freighting with teams is 25 cts. per ton-mile. Cost records for one year have been compiled to compare with the accepted figure (of 25 cts. per ton-mile). The two have been found to agree closely.

The cost of feeding the horses being as above given, the wages of teamster may be added, and a tolerably close estimate made of the cost of hauling over good roads. The depreciation of the horses, harness and wagons is quite an important item, however, as it probably ranges between 15% and 30% per annum. On this point we shall welcome any data from contractors who have had long experience in teaming.

There is another point on which opinion is by no means settled, and that is the distance that a horse can travel daily, going loaded and returning empty. The range is 16 to 25 miles, varying with

the character of the roads, the load hauled, and the length of the job. We mention the latter factor because on short jobs it is often possible to hire teams and get 25% more work out of them than would be possible were the same teams employed continually. When working horses lose weight steadily, it is obvious that they are being overworked, but on short jobs the loss in weight is not visible to the eye, although such a loss may be occurring. We would suggest the advisability of frequently weighing each horse, if scales are available, with a view to determining accurately its capacity for work under any given conditions. Contractors are too apt to accept the word of teamsters on this point, sometimes resulting in injury to the horses by overworking, and, on the contrary, not infrequently causing a loss through not working the horses to their capacity.

THE EQUIPMENT OF ENGINEERS GOING TO PANAMA.

By Henry A. Harris,* Jun. Am. Soc. C. E.

Many American engineers who are considering the advisability of accepting positions under the Government on the Isthmus of Panama have had little or no experience in tropical work, and the writer, having been requested to furnish some data on the subject, wishes to submit a few general notes to fellow-members of the profession, in the hope that they may prove of some value. They are written solely for the use of those who have never been in the tropics, and who have not a clear idea of the requirements of tropical work.

So much has been written lately descriptive of the climate, the people, and the work in general, that it will be unnecessary to more than touch on those points.

Leaving New York at any time before the middle of April or first of May, one should be prepared to experience both wintry cold and tropical heat during the six-day steamer voyage. Starting out from New York with heavy winter clothes and underclothes, the thinnest and coolest summer wearing apparel should be conveniently placed in one's trunk, so as to be easily accessible for a complete change after four or five days out. The writer once left Mexico in the middle of April, sweltering in as light clothing as decency allowed, and suffered greatly from the cold off the New Jersey coast in the latter part of the month, although he had made a complete change to the heaviest winter clothes possible.

On arrival at the Isthmus, the climate *appears* to be very similar to that in other Central American and West Indian countries. It is much cooler in the hills of the interior, near Bas Obispo, for example, than in either Colon or Panama. The heat in Colon is rather oppressive, and Panama City itself is very hot during the daytime. The hilly country around Gorgona, Matachin, Bas Obispo and up the tributaries of the Chagres River, has really a very pleasant climate, with almost invariably cool nights. The nights in Panama are also, as a general thing, quite cool enough for pleasant sleep. The *healthfulness* of the climate, however, does not compare at all favorably with Central America and the West Indies.

In the matter of clothing for use on the Isthmus, one should perhaps differentiate somewhat between life in Colon or Panama and that out on the Canal line and in the camps on the upper Chagres; but as very few engineers will be able to know definitely whether they will be on the Canal line or stationed in Panama or Colon six months or a year hence, I would suggest that an outfit be taken which will cover the requirements of either location. In the two cities very much the same clothing would be worn as is used in the hottest periods of summer in the States. To this should be added several suits of khaki or linen duck; crash suits will be found very light and cool.

For work in the interior of the Isthmus and outside of the cities, a somewhat different outfit will prove more useful; any good felt hat, such as the U. S. Army hat, or a Stetson; medium weight wool or wool and cotton underwear and socks, khaki suits, outing flannel or light wool and cotton negligé shirts, three or four pairs of heavy shoes, stout canvas or leather leggings, and an oil rain coat. A good pair of woolen blankets and an air pillow (15 × 24 ins.) will not come amiss. Excellent mosquito bars were furnished by the Commission to the parties who arrived on the Isthmus in June, and their nightly use is absolutely imperative. The woolen underclothes are a great protection against chill when exposed to sudden tropical downpours. Leather leggings have proved very satisfactory to the writer, who has used them for years in the tropics, under conditions similar to those in Panama. They should be of the winding-strap form known as "puttees." Very good khaki suits may be had in Panama City for from $5 to $10 per suit, and riding trousers of the same material (to be worn with the puttees) for $3 to $3.50. Crash suits may be bought for $4 or $5, and German wool underwear for $3 or $4 a suit. It is more economical to bring shoes, hats, and perhaps the leggings, shirts and blankets from the States, though all but the blankets may be obtained on the Isthmus. Leather knee boots or three-quarter boots are very useful in the rainy season (which is of far greater duration than in Central America or the West Indies).

It is advisable to be prepared with a few simple medicines and drugs, and have them on hand for immediate use. The camps on the Upper Chagres were very meagerly supplied by the Commission with even the simplest remedies, and the writer found almost constant use for the few which he had in his personal kit. The following may prove useful:

200 2 gr. Quinine pills,
500 Cascarines, Comp. (Bell & Co., New York).
200 Diarrhoea.
8 or 10 oz. Salts,
Calomel,
8 oz. Creoline (Panama or Colon).

There is great tendency toward constipation during the first month or two in the tropics, and daily use of the Cascarines for three or four weeks will usually regulate this. Constipation should never be allowed to go unheeded, as it may easily turn into serious trouble. Sudden cold in the stomach or bowels must be averted, and woolen underwear in the day and woolen abdominal bands worn at night will do much to prevent chill. Over-exertion and over-heating should also be avoided, as either may readily bring on an attack of fever.

The nature of the work in the cities will not materially differ from non-tropical localities. The work on the line, however, is very different. There the work is strenuous indeed, and none but very strong men, physically and mentally, should attempt it. The effect of the climate cannot be foretold, as it is largely a matter of personal equation; where one man will feel no harmful effects, another under precisely the same conditions, although apparently well fitted for the work, may be made very miserable and finally be forced to leave after a few months. Temperance is very essential; many hard drinkers have lived apparently successfully for years in the tropics, under trying circumstances; but when their time comes, *it comes suddenly.*

On the line one must be prepared for intense heat, sudden drenchings, and the voracious and ever-present "garapote," or tick. The latter is a very uncomfortable insect, which burrows his head under the skin, and the more one scratches the worse the sore becomes. A solution of one tablespoonful of creoline to a quart of water, using an ounce or so every night on the legs, has been found very efficacious. This is a remedy much used in Guatemala for the same purpose, and has proved successful on the Isthmus. Rum and camphor is very soothing in the case of insect bites, and is also recommended.

The French Company built hundreds of small one to three-room cottages all along the line of the canal, to be used as quarters for the officers and laborers. Many of these houses are in poor repair, but are being renovated by the Commission, and occupied by the engineers and inspectors now in the field. The situation of a great part of these quarters leaves little to be desired, and many are located on the hilltops, with good exposure, fine air and really beautiful outlook. The writer has seldom seen a more ideally placed or more satisfactory camp than the group of buildings at Bas Obispo, including the fine old "Maison Presidencial," now the headquarters of Mr. Boyd Ehle, Resident Engineer of the Bas Obispo division. These quarters are furnished the employees at no expense, and will compare more than favorably with quarters in other tropical countries.

In Panama City there are very few Government quarters available at present, but Governor Davis has in contemplation the erection of a number of cottages and one or two dormitories in the neighborhood of Ancon Hill. At present rents are abnormally high in the city. A furnished room brings from $10 per month up. The writer paid $12 for a room in a private family, and partly furnished it himself. This same house, a massive old brick and stone building, formerly rented for less than $30; it now rents for over $50. The same is true all over the city. One small frame house of only four or five rooms was offered at about $30 per month, and it was not in a desirable locality. This rent inflation will subside when the Government builds quarters.

At the principal hotel in Panama the daily rates are $3.50 per day (American plan), and the table and service are far below average. This will not bear comparison with prices elsewhere for *better* accommodations, viz.: Mexico, $2.50 to $3; Guatemala City, $1 (!); San Juan, Porto Rico, $2.50.

There is a large market in Panama City, with plenty of green vegetables, and it should not be difficult to set a fair table. All fruits are, of course, plentiful and cheap. There is a Chinese garden on the outskirts of the city, where a great variety of vegetables are grown for the market. Kitchen and dining-room utensils, crockery and china-ware, all kinds of hardware, and, to some extent, furniture, may all be obtained in the shops, though furniture is rather high-priced. There are native cabinetmakers who can turn out good mahogany furniture if given time; this will prove substantial, while perhaps rather costly. Generally speaking, prices are rather high in Panama; almost any article desired may be purchased, but sometimes the figure is excessive.

Concerning the character of the work, the salaries paid to engineers, etc., the writer will present a few facts coming within his own personal experience, from which the reader can draw his own conclusions:

The Resident Engineer on the Bas Obispo division is a man of many years' experience on tropical canal work in Nicaragua, Isthmus of Darien and Panama, having been connected with the Nicaragua Canal surveys back in 1888. He is a man of iron constitution, an engineer of unusual capabilities, and possesses to a marked degree the individuality which makes him successful in managing men. He receives a salary of $300 per month.

On his division are two complete field parties. The Chief of one of these, under whose direction the writer had the pleasure of working on the Pacific Spillway survey, is also an old timer on tropical work. He was on the Nicaragua Canal in 1889, and is also a man of exceptional physique and engineering capacity. His party consists of six to eight American engineers, and a dozen unruly natives. He has all the responsibility of a large camp and of work done under the most trying conditions. This Chief of Party is ranked as an "Instrument-man" (at a salary of $175 per month). Other instances might also be mentioned, but space will not permit, and a comprehensive idea of the responsibilities implied in the Isthmian Service may be formed from these two instances. The salaries received by these men might be considered fair for such healthful surroundings and pleasant conditions as are to be found in Mexico and the West Indies; but when one considers the responsibilities of their positions, the trying character of the work, and the too frequently fatal effects of the locality and climate, it must be admitted that the salaries paid are unjustifiably inadequate to the results achieved.

Judging from the undercurrent of disillusionment and discontent among the engineers now on the work, the Panama Canal will never be completed under the existing scale of salaries.

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The Canal work under the supervision of the United States is very much in its infancy, and there are many unpleasant features at present which time and administrative efforts may certainly be relied upon to greatly improve. Just at this stage of the undertaking there are some insurmountable difficulties, and many which might have been solved before this, and there is a general feeling of unrest on the Isthmus. The engineer who contemplates going to Panama under existing conditions should obtain all the definite information possible, and carefully weigh the evidence before taking the decisive step.

FIG. 1. WRECK OF A RUNAWAY IRON ORE TRAIN; VIEW FROM END OF EMBANKMENT; CARS IN THE DISTANCE.

A REMARKABLE WRECK OF A RUNAWAY IRON ORE TRAIN ON THE LAKE CHAMPLAIN & MORIAH R. R.

A man on Norwegian skis has been known to make a leap exceeding 100 ft., measured horizontally, but a man on a locomotive near Port Henry, N. Y., might have broken this record last week by some 200 ft. had he remained at the throttle. The accompanying photographs, Figs. 1 and 2, show, however, that the engineer was wise in allowing the train to "go it alone."

On Feb. 16 a locomotive and a train of seven steel gondola cars, each loaded with 55 tons of iron ore, started from the mines of Witherbee, Sherman & Co., at Mineville, N. Y., on their way to Port Henry. After the train had gone some distance the engineer attempted to shut the throttle at the head of a steep grade, but was unable to move it. The crew made a hasty but vain attempt to apply the brakes, and then jumped. For about two miles, down a 4% grade, the train ran until it reached the end of a switchback, shown in the plan of Fig. 3, and then it made the record leap, in which it is believed that the locomotive traveled 340 ft. horizontally through the air, with the full train attached, before striking the ground. The velocity of the train probably reached 100 miles an hour.

Perhaps the most remarkable feature of this accident is the fact that the cars possessed any salvage value afterward; but the manufacturers, the Pressed Steel Car Co., have agreed, we understand, to repair each car for $500, which is slightly less than half the first cost to the purchasers. Each of these cars weigh 29,600 lbs., and is designed to carry 100,000 lbs., but the actual load is usually considerably more.

The road on which this accident occurred is the Lake Champlain & Moriah R. R., which handles the iron ore from the mines of Witherbee, Sherman & Co. and the Port Henry Iron Ore Co. We are indebted to the courtesy of Mr. Frank S. Witherbee, President of the company, for the photographs here reproduced and for information regarding the circumstances of the disaster.

A TABLE FOR DEPRECIATION OR SINKING FUND PAYMENTS, WITH ANNUAL COMPOUNDING.

In our issue of Oct. 21, 1897, a table* for depreciation or sinking fund calculations was given by Mr. Peter Mogensen. That table was based on semi-annual interest payments, and interest compounded semi-annually. To cover the more usual case of annual interest payment, Messrs. Charles C. Moore & Co., Engineers, of San Francisco, Cal., have computed the table which is reproduced herewith.

The table is in two parts, the first giving the amount of one of the equal annual payments in dollars per dollar investment, for various terms of amortization and various rates of interest; while the second gives the term of amortization, or "life of plant," for various percentages of depreciation and various rates of interest.

To illustrate the method of using the table, the following two examples may be of service:

1. A given equipment of machinery, costing $25,000, is estimated to have a useful life of 14 years. At the end of that time it will have a scrap value of $1,000. The money earned by the plant receives interest at 4%, payable annually. What annual charge must be made to extinguish the principal by the time the machinery must be renewed? The sum to be made up is $25,000 − $1,000 = $24,000, in 14 years. The first page of the accompanying table gives, for 14 years and 4%, the payment $0.5467 per dollar. The annual depreciation debit is, therefore, $24,000 × .0547 = $1,312.08. In addition to this, of course, interest must be paid on the $25,000 investment; the rate of interest is not necessarily the same as the 4% above used, since it depends on the conditions under which the capital was borrowed.

2. A system of water-pipes for city distribution cost $125,000. Besides the interest on the bonds, the system is charged annually with $2,500 (2%) depreciation. In what time will the sum thus accumulated, earning 5% interest, paid annually, be sufficient to pay for the bonds at par? At 4% premium? From the second part of the table we find, for 2% depreciation and 5% interest, the figure 25.68 years. This represents the time required to wipe out the debt at par. If 104% must be paid back, then the equivalent depreciation payment is 2% ÷ 1.04 = 1.9231, and the table does not suffice directly. Using, then, the formula from which the table was computed:

$$N = \log\left(\frac{R + x}{x}\right) \div \log(1 + R),$$

we obtain

$$N = \log \frac{.05 + .019231}{.019231} \div \log 1.05$$

$$= \log 3.60 \div \log 1.05 = \frac{0.55630}{0.02119} = 26.25 \text{ years.}$$

The formulas on which the present table is based are old and well known, but the contribution of Moore & Co. is the table computed from these formulas for interest compounding annually. This table, together with the table for semi-annual compounding given last in our issue of Sept. 29, 1904, will enable the ready solution of a large range of problems that occur rather frequently.

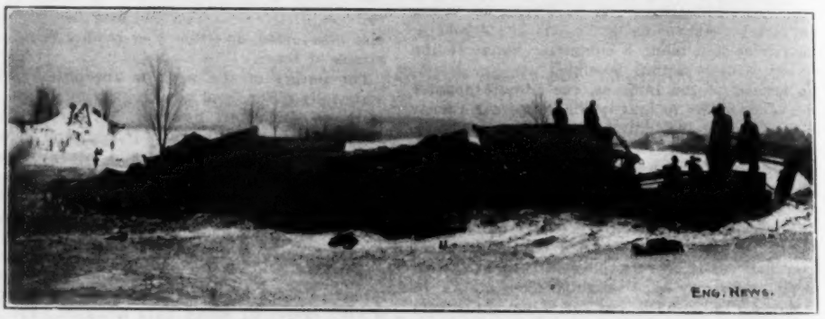


FIG. 2. WRECK OF RUNAWAY IRON ORE TRAIN; END OF SWITCHBACK IN THE DISTANCE.

In connection with this subject we may refer the reader to a brief discussion of several sinking-fund formulas in our issue of Dec. 2, 1897, p. 362, and to a formula for varying annual installments, given in our issue of March 24, 1904, p. 284.

*Reprinted, on request, in our issue of Sept. 29, 1904.

Tables for Computing Depreciation or Sinking Fund Payments for Interest Compounded Annually.—By C. C. Moore & Co., Engineers, San Francisco, Cal.

Annual payment per dollar invested, to repay original outlay at the end of a given number of years.

Formula:

$$x = \frac{R}{(1 + R)^N - 1}$$

N = No. of years, term of amortization.
R = Rate of interest received.
x = Rate of depreciation charge, or annual sinking-fund instalment in dollars per dollar.

Life of plant (years).	Annual instalments—$. Rates of interest on instalments—%. 3%	4%	5%	6%	8%
10.....	$.08723	$.08330	$.07950	$.07587	$.06903
11.....	.07808	.07416	.07039	.06679	.06008
12.....	.07046	.06656	.06283	.05928	.05269
13.....	.06403	.06015	.05646	.05296	.04652
14.....	.05853	.05467	.05103	.04759	.04130
15.....	.05376	.04994	.04634	.04296	.03683
16.....	.04961	.04582	.04227	.03895	.03298
17.....	.04595	.04220	.03870	.03544	.02963
18.....	.04271	.03899	.03555	.03236	.02670
19.....	.03981	.03614	.03275	.02962	.02413
20.....	.03722	.03358	.03024	.02718	.02185

Term of amortization when a given percentage of the original outlay is paid into the sinking fund annually.

Formula:

$$N = \frac{\log \frac{R + x}{x}}{\log(1 + R)}$$

Depreciation of plant, %	Life of plant in years. Rates of interest on instalments—%. 3%	4%	5%	6%	8%
1.....	46.90	41.04	36.73	33.40	28.55
2.....	31.00	28.01	25.68	23.79	20.91
3.....	23.45	21.60	20.10	18.85	16.88
4.....	18.93	17.67	16.62	15.73	14.28
5.....	15.90	14.99	14.21	13.53	12.42
6.....	13.72	13.02	12.42	11.90	11.01
7.....	12.05	11.52	11.04	10.62	9.90
8.....	10.77	10.34	9.95	9.60	9.01
9.....	9.72	9.37	9.05	8.76	8.26
10.....	8.88	8.58	8.31	8.07	7.64
11.....	8.16	7.91	7.68	7.47	7.10

COST OF LAYING A 12-IN. WATER PIPE ACROSS A RIVER.

It is not often that an accident cheapens the cost of work and discloses a simpler way of accomplishing the desired end. The following account of how a 500-ft. line of 12-in. water pipe was laid, partly according to design and partly not according to design, may prove profitable to any one having similar work to do.

Across a river, 500 ft. wide and about 4 ft. deep, a trench was dredged 6 ft. deep, making a depth of 10 ft. from the water surface to the bottom of the trench. Then A-frame bents were built 12 ft. center to center, with the legs straddling the trench and the horizontal member of the "A" not far above the water. The timber used in the bents was 4 × 6-in. hemlock, and was bolted together on a raft, from which each bent was erected and stay-lathed to the next preceding bent. A ⅝-in. threaded rod, 12 ft. long, and provided with a hook at its lower end, was passed through a vertical hole bored in the center of the horizontal member of each "A," and the hook was hooked into an iron ring or collar around the end of each of the cast-iron pipes. Each of these rods was provided with a nut, by the turning of which it was intended to lower the pipe line after the pipe joints had been leaded and calked. The pipe, it should be stated, was the ordinary water pipe, and only two flexible joints were provided, one on each side of the river. There were 43 lengths of pipe, so that it would have required 43 men manipulating monkey-wrenches to have lowered the full line at once; but, as it seemed unnecessary to have so many men, the regular gang of 10 men was used. Each man was directed to make one full turn of the nut on the rod assigned to him, upon hearing the signal from a whistle. After making a few turns, the gang was moved to the next ten rods, which were given the same number of turns, and so on.

For a time this plan seemed to be working nicely. Whether from carelessness or through mischief, some of the men did not obey the signals, and turned the nuts assigned to them more rapidly than other men. This resulted in throwing additional weight on to some of the rods, which finally caused one of the hooks to break. Immediately the next hook gave way, and, accompanied by a regular tattoo of snapping rods, the whole pipe line sank into the river, and went gently to the bottom. An immediate inspection along the line showed only one joint where any considerable amount of air was escaping in bubbles. One of the men volunteered to dive down, hammer in hand, and calk this joint, which he succeeded in doing perfectly.

Some uneasiness was felt as to the condition of the pipe line, so a regular diver was telegraphed for. He arrived the day following, and his examination showed every joint to be in good condition, and the pipe line resting in a straight line upon the bottom of the trench.

From this experience it would seem to be safe and practicable to lower a similar pipe line by intention exactly as this line was lowered by accident. Each pipe could be supported by a wire just strong enough to carry its weight until the joints were leaded and calked, then upon cutting one of the wires near the shore end, the rest would break in succession, letting the whole line descend. As the pipe line is filled with air, it is quite buoyant when under water, and does not go down to the bottom with a rush and a shock, but settles down gently. In case it should become necessary to repair a break, threaded rods could then be made, and the whole line lifted at but slightly greater expense than would have been incurred had rods been used in the first place.

The labor cost of building 44 A-frames, placing and calking this pipe line, was as follows:

10 men, 3 days, at $1.75	$52.50
1 foreman, 3 days, at $3	9.00
10 men, 1 day lowering pipe	17.50
1 foreman, 1 day lowering pipe	3.00
1 driver, 1 day	25.00
Traveling expenses of diver	15.00
Total for 516 ft. of pipe	$122.00

BRITISH STANDARD SPECIFICATIONS FOR PORTLAND CEMENT.

The recent adoption of standard specifications for cement by the American Society for Testing Materials lends interest to the standard specification for Portland cement recently adopted by the Committee on Cement of the Engineering Standards Committee of Great Britain, and finally adopted by the main committee on Nov. 23, 1904. The Committee on Cement began its work in March, 1903, and completed its work in November, 1904. The following are the specifications adopted:

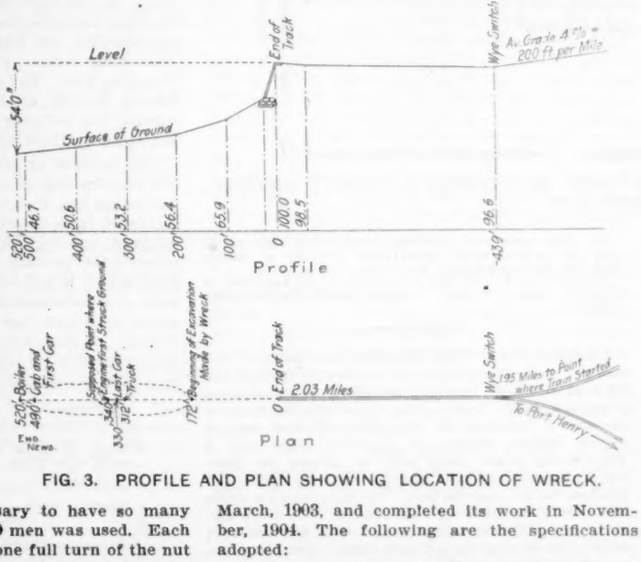


FIG. 3. PROFILE AND PLAN SHOWING LOCATION OF WRECK.

QUALITY AND PREPARATION.—(1) The cement is to be prepared by intimately mixing together calcareous and argillaceous materials, burning them at a clinkering temperature and grinding the resulting clinker. No addition of any material is to be made after burning, except when desired by the manufacturer, and if not prohibited in writing by the consumer, in which case calcium sulphate or water may be used. The cement, if watered, shall contain not more than 2% of water, whether that water has been added or has been naturally absorbed from the air. If calcium sulphate is used, not more than 2% calculated as anhudrous calcium sulphate of the weight of the cement shall be added.

SAMPLING AND PREPARATION FOR TESTING AND ANALYSIS.—(2) As soon as the cement has been bulked at the makers' works,* or on the works in connection with which the material is to be used, at the consumers' option, samples for testing are to be taken from each parcel, each sample consisting of cement from at least twelve different positions in the same heap, so distributed as to ensure, as far as is practicable, a fair average sample of the whole parcel, all to be mixed together and the sample for testing to be taken therefrom.

(3) Before gaging the tests, the sample so obtained is to be spread out for a depth of 3 ins. for 24 hours, in a temperature of 58 to 64° F.

(4) In all cases where consignments are of 100 tons and upwards, samples selected as above from each consignment, either at the makers' works or after delivery at the works where the cement is to be used, are to be sent for expert testing and for chemical analysis. In no case is cement so tested and analyzed to be accepted, or used, unless previously certified in writing by the consumer to be of satisfactory quality. Payment for such tests and analyses to be made by the consumer, the manufacturer supplying the cement required for the same free of charge. When consignments of less than 100 tons have to be supplied, the makers shall, if required, give certificates for each delivery, to the effect that such cement complies with the terms of this standard specification, with regard to quality, tests and chemical analyses, no payment being made by the consumer for such certificate nor for the making of such tests and analyses.

(5) Should it be deemed more convenient by the consumers that the samples for testing should be taken at the makers' works before delivery, the latter are, in that event, to afford full facilities to the inspector, who may be appointed by the consumers to sample the cement as he may desire at the maker's works, and subsequently to identify each parcel as it may be despatched, with that sampled by him. No parcel is to be sent away unless a written order has been previously received by the makers from the said consumer to the effect that the material in question has been approved.

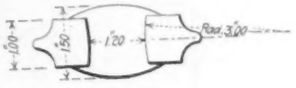
FINENESS AND SIEVES.—(6) The cement shall be ground to comply with the following degrees of fineness, viz.:

The residue on a sieve 76 × 76 = 5,776 meshes per sq. in. is not to exceed 5%.

The residue on a sieve 180 × 180 = 32,400 meshes per sq. in. is not to exceed 22½%.

The sieves are to be prepared from standard wire, the size of the wire for the 5,776 mesh is to be .0044-in., and for the 32,400 mesh, .0018-in. The wire shall be woven (not twilled), the cloth being carefully mounted on the frames without distortion.

SPECIFIC GRAVITY.—(7) The specific gravity of the cement shall be not less than 3.15 when sampled and hermetically sealed at the maker's works, nor less than 3.10 if sampled after delivery to the consumer.



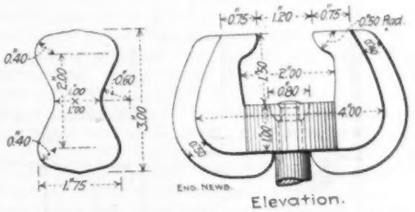


Fig. 1. British Standard Cement Briquette.

Fig. 2. Standard Clip for Holding Cement Briquette.

CHEMICAL COMPOSITION.—(8) The cement is to comply with the following conditions as to its chemical composition. There shall be no excess of lime, that is to say, the proportion of lime shall be not greater than is necessary to saturate the silica and alumina present. The percentage of insoluble residue shall not exceed 1.5%; that of magnesia shall not exceed 3%, and that of sulphuric anhydride shall not exceed 2.5%.

TENSILE TESTS.—(9) The quantity of water used in gaging shall be appropriate to the quality of the cement, and shall be so proportioned that when the cement is gaged it shall form a smooth, easily worked paste, that will leave the trowel cleanly in a compact mass. Fresh water is to be used for gaging, the temperature thereof, and of the test room at the time the said operations are performed, being from 58 to 64° F.

The cement gaged as above is to be filled, without mechanical ramming, into molds of the form shown in Fig. 1, each mold resting upon an iron plate until the cement has set. When the cement has set sufficiently to enable the mold to be removed without injury to the briquette, such removal is to be effected. The said briquette shall be kept in a damp atmosphere and placed in fresh water 24 hours after gaging, and kept there until broken, the water in which the test briquettes are submerged being renewed every seven days, and the temperature thereof maintained between 58 and 64° F.

NEAT TESTS.—(10) Briquettes of neat cement of the shape shown in Fig. 1 are to be gaged for breaking at 7 and 28 days, respectively, six briquettes for each period. The average tensile strength of the six briquettes shall be taken as the accepted tensile strength for each period. For breaking, the briquette is to be held in strong metal jaws, of the shape shown in Fig. 2, the briquettes being slightly greased where gripped by the jaws. The load must then be steadily and uniformly applied, starting from zero, increasing at the rate of 100 lbs. in 12 seconds. The briquettes are to bear on the average not less than the following tensile stresses before breaking.

7 days from gaging.....400 lbs. per sq. in. of section
28 days from gaging.....500 lbs. per sq. in. of section

The increase from 7 to 28 days shall not be less than:

25% when the 7-day test falls between 400 to 450 lbs. per sq. in.

20% when the 7-day test falls between 450 to 500 lbs. per sq. in.

15% when the 7-day test falls between 500 to 550 lbs. per sq. in.

10% when the 7-day test falls between 550 lbs. per sq in. or upwards.

SAND TESTS.—(11) The cement shall also be tested by means of briquettes prepared from one part of cement to three parts by weight of dry standard sand, the said

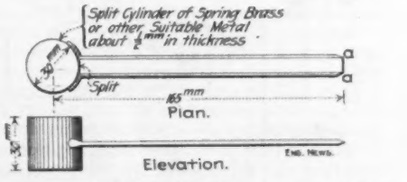


Fig. 3. Apparatus for Conducting the "Le Chatelier" Test.

briquettes being of the shape described for the neat cement tests, the mode of gaging, filling the molds, and breaking the briquettes is also to be similar. The proportion of water used shall be such that the mixture is thoroughly wetted, and there shall be no superfluous water when the briquettes are formed. The cement and sand briquettes are to bear the following tensile stresses:

7 days from gaging.....120 lbs. per sq. in. of section
28 days from gaging.....225 lbs. per sq. in. of section

The increase from 7 to 28 days shall not be less than 20%.

The standard sand referred to above is to be obtained from Leighton Buzzard. It must be thoroughly washed, dried and passes through a sieve of 20 × 20 meshes per sq. in., and must be retained on a sieve of 30 × 30 meshes per sq. in., the wires of the sieve being .0164-in. and .0108-in., respectively.

SETTING TIME.—(12) There shall be three distinct

*Should the consumer desire to stipulate for any special quantity, the size of the heap should be stated.

gradations of setting time, which shall be designated as "quick," "medium" and "slow."*

Quick.—The setting time shall be not less than ten minutes, or more than 30 minutes.

Medium.—The setting time shall be not less than half an hour or more than two hours.

Slow.—The setting time shall be not less than two hours, or more than five hours.*

The temperature of the air in the test room at the time of gaging and of the water used is to be between 58 and 64° F.

The cement shall be considered as "set" when a needle having a flat end 1-16-in. square, weighing in all 2¼ lbs., fails to make an impression when its point is applied gently to the surface.

SOUNDNESS.—(13) The cement shall be tested by the Le Chatelier method, and is in no case to show a greater expansion than 12 millimeters after 24 hours aeration and 6 millimeters after 7 days aeration.

Note.—The apparatus for conducting the Le Chatelier test (Fig. 3) consists of a small split cylinder of spring brass or other suitable metal of 0.5 millimeter (.0197-in.) in thickness, 30 millimeters (1.1875 ins.) internal diameter, and 30 millimeters high, forming the mold, to which on either side of the split are attached two indicators 165 millimeters (6.5 ins.) long from the center of the cylinder, with pointed ends A A, as shown upon the sketch.

In conducting the test, the mold is to be placed upon a small piece of glass and filled with cement gaged in the usual way, care being taken to keep the edges of the molds gently together while this operation is being performed. The mold is then covered with another glass plate, a small weight is placed on this and the mold is immediately placed in water at 58 to 64° F. and left there for 24 hours.

The distance separating the indicator points is then measured, and the mold placed in cold water, which is brought to a boiling point in 15 to 30 minutes, and kept boiling for six hours. After cooling, the distance between the points is again measured, the difference between the two measurements represents the expansion of the cement, which must not exceed the limits laid down in this specification.

(14) The tests and analyses hereinbefore referred to shall in on case relate to a larger quantity of cement than 250 tons sampled at one time.

ACCEPTANCE.—(15) No cement is to be approved or accepted unless it fully complies with the foregoing conditions.

*When a specially slow-setting cement is required the minimum time of setting shall be specified.

*When a specially slow-setting cement is required the minimum time of setting shall be specified.

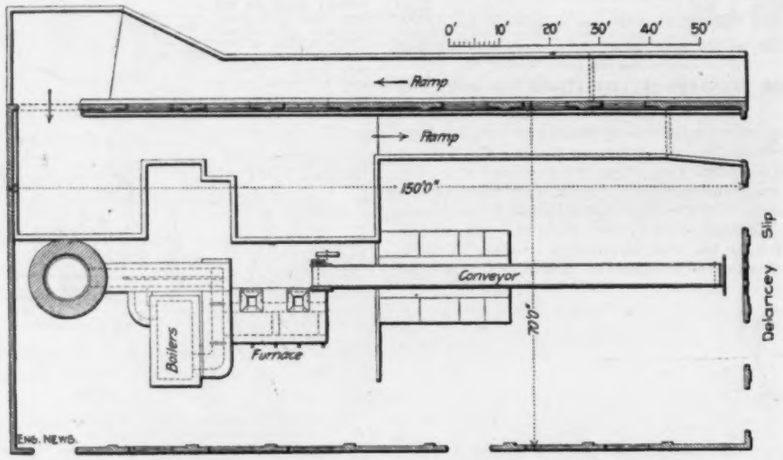


FIG. 1. PLAN OF RUBBISH INCINERATOR PLANT, DEPARTMENT OF STREET CLEANING, NEW YORK CITY.

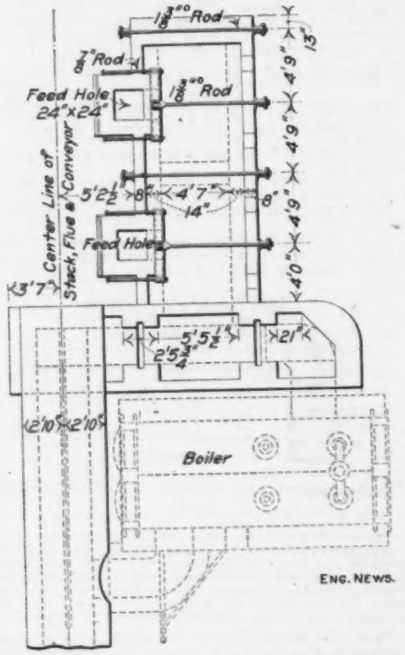


Fig. 2. Top Plan of Furnace for Rubbish Incinerator Plant.

A VACUUM CESSPOOL CLEANER with receiving tank mounted on a self-propelled vehicle has been designed and built at Romford, England, by Merryweather & Sons, Greenwich Road, London. On a four-wheeled truck is mounted a 840-gallon (U. S.) galvanized steel tank, a duplex vertical engine, a coal-fired boiler and a direct-acting steam pump and an injector for feeding the boiler. The main engine propels the vehicle and exhausts the air from the tank. The air pumps are above and directly connected with the engines. The whole machine weighs 7½ long tons and has a rated speed of about eight miles an hour on ordinary roads. Aside from the use of mechanical power for creating a so-called vacuum in the tank and for propelling the truck the outfit does not greatly differ in working principle from the odorless excavators in use in this country. A notable exception, however, claimed for the apparatus is the passage of the exhaust air from the tank through the fire beneath the boiler, but whether the temperature is high enough to deodorize this air and whether or not the air would be much of a nuisance or any menace to health if discharged into the open air are questions open to discussion. A view of the machine is published in both "Engineering" and "The Engineer" of London for Nov. 25.

PROPOSED CREMATORY FOR STREET SWEEPINGS AND LIGHT REFUSE, NEW YORK CITY.

About three years ago the city of New York constructed at the foot of West 47th St. an experimental plant for burning certain portions of the refuse colleced by the Department of Street Cleaning. The plan was to exclude ashes and street sweepings from this crematory, burning only the lighter refuse, such as waste paper, excelsior and packing boxes. Recently plans have been prepared by Mr. H. De B. Parsons, M. Am. Soc. C. E., for a second crematory of the same general type, but modified so as to handle street sweepings as well as the lighter refuse described above. The Department of Street Cleaning is now asking bids for the construction of this crematory and we, therefore, give space to illustrations and a brief description of its characteristic features.

The new crematory is to be located at Delancey Slip, between Tompkins and East Streets, in Manhattan, and will be housed in a special brick building. Fig. 1 is a plan of the house and crematory and their appurtenances. The furnace is fed at the top from an elevated charging platform. The paper carts entering the building will unload on an inclined conveyor reaching to the charging platform and passing between two rows of hoppers. As the light refuse passes up the conveyor the merchantable material will be sorted out and thrown into the hoppers on each side, and the remaining refuse will be discharged onto the charging floor. The street sweeping carts will discharge directly on the same floor, entering and leaving the building by means of the two ramps indicated on the plan.

The furnace or crematory proper is shown in top plan by Fig. 2 and in section by Fig. 3. Referring to Fig. 2, it will be seen that the material is pushed from the charging floor into two feeding hoppers, one for each cell of the furnace. The construction of these hoppers is shown by Fig. 4, from which it will be seen that they are provided with counterbalanced cast-iron covers. The flues are so arranged that the furnace gases may pass directly to the chimney or be switched through boilers located between the furnace and the chimney. The present arrangement is to omit the boilers until they are needed some time in the future. The front of the furnace is provided with the usual doors for stoking purposes.

Fig. 3 shows the interior construction of the furnace. It consists, as will be seen, of two cells separated by a high brick wall, so that by feeding first one cell and then the other there is always a sufficiency of hot gases to prevent the fresh charge from smoking. Fig. 5 is a section showing the construction of the flue by which the furnace gases are led by the boilers to the chimney. The furnace construction calls for no particular mention. All walls are built of common brick and are lined with fire-brick wherever exposed to hot gases. The stack is to be built of hollow radial molded blocks.

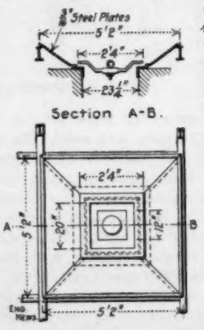


Fig. 4. Details of Feed Holes and Covers for Furnace.

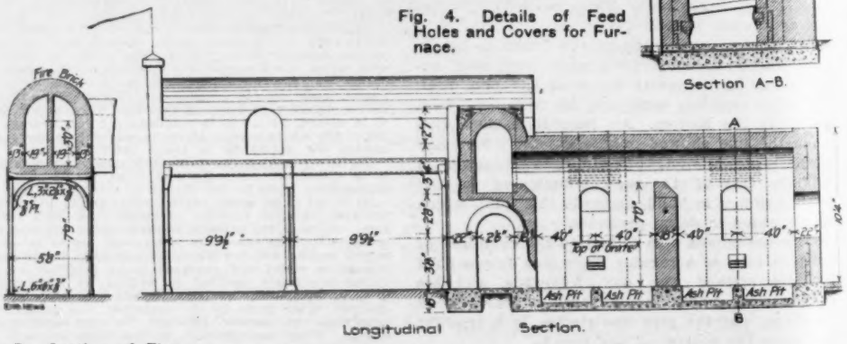


Fig. 5. Section of Flue from Furnace to Chimney.

FIG. 3. SECTIONS OF FURNACE FOR RUBBISH INCINERATOR PLANT.

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An official recommendation for a sea level canal at Panama has now been made by the engineering committee of the Panama Canal Commission, Messrs. Wm. H. Burr and W. B. Parsons. That such a recommendation was likely to be made has been evident for some time from information gleaned from unofficial sources; and, in fact, the official report of the Commission, printed in our issue of Jan. 26, gave evidence that such a conclusion was a very probable one.

The adoption of the sea-level plan will mean an increase in cost of about $80,000,000 over the cost of a canal with locks and a summit level of 85 ft. above tide water, recommended by the former Isthmian Commission, and it will also mean a probable increase in time of construction of two to six years over the time required for a lock canal. The final decision whether this change in plan shall be adopted, therefore, will have to be made by Congress. To quote from a paper by Chief Engineer John F. Wallace, in the March number of "The World To-day":

> The decision as to the final plan should be made by the American people, as represented by their Congress, which body should take the responsibility therefor and should be the one to decide this great question, after having been duly advised of all the elements which enter into the problem, through the Isthmian Canal Commissioners and the expert engineers constituting its membership, assisted by such other professional advice as it may consider necessary to employ.
>
> This greater problem is one which the chief engineer is not called upon to decide, and upon which he has as yet expressed no official opinion, either in regard to time or cost, the public press to the contrary, notwithstanding.

The present Congress, however, expires on March 4, and cannot be expected to even attempt a decision on a matter of such large importance at so late a period in the session. The actual decision, therefore, as to a sea-level or lock canal at Panama will have to go over to next December unless the President should convene Congress in extraordinary session at an earlier date.

That in the long run Congress will adopt the recommendation of the Commission there is little reason to doubt. This is emphatically a field where the only safe course is to be guided by the opinions of experts, and of experts who have given that thorough study to the technical features of the problem which is necessary for fair judgment. It may be, indeed, that Congress or the President may think it wise to request a special Board of Engineers to report on the question of the sea-level plan vs. locks; but this seems, on the whole, unlikely. In the long run, the public, and Congress as its representative, must accept the opinions of some body of engineering experts; and if a new engineering board were to be created to pass upon the sea-level proposition, it would be difficult to select men who would command and deserve a greater degree of public confidence than the engineering members of the present Canal Commission.

Of course, before the sea-level canal is formally adopted by Congress, it is to be expected that the entire plans for the sea-level canal and the considerations which have brought about its adoption by the Commission, will be fully published and made accessible for free public discussion and criticism, and strong advocates of a lock canal will doubtless be heard from. Until such publication is made, intelligent discussion of sea level vs. locks will be hardly possible.

It is worth particular notice that the point on which the choice of a sea-level canal appears to have turned was the rate and cost of excavation work in the Culebra cut. The Commission, from the records of actual work already done at Culebra with a working force and equipment that is admittedly not up to a high standard, concludes that an average output of 1,000 cu. yds. per steam shovel per working day, and an average total cost of 50 cts. per cu. yd., will be fair figures on which to base the cost of the cube to be excavated at Culebra. To refresh our readers' recollection, we may state that the cutting at Culebra is nearly 8 miles long, with a maximum depth of about 300 ft., and that the material to be excavated is for nearly all the distance classed as a very hard clay.

Some hundreds of engineers and contractors who are looking toward Panama as a possible future field of work, find themselves confronted with some practical questions as to the manner of life on the Isthmus, the accommodations available, the possibilities of housekeeping by men accompanied by families, the cost of living, the clothing to be taken from the United States or bought on the Isthmus.

In order to furnish practical advice on such questions as these, we have obtained a paper on this subject from an engineer who has spent nearly a year on the Isthmus as a member of the Commission's engineering staff, and who also, from extended previous experience on engineering work in the tropics, is particularly competent to speak with authority. His article, in another column of this issue, will be appreciated, we are sure, by any of our readers who may be looking forward to work on the Isthmus.

It is an open secret, we believe, that a considerable amount of discontent has been prevalent among the engineering staff at Panama. Where the responsibility for this lies we cannot undertake to say; but its chief source appears to have been a misunderstanding on the part of engineers going from the United States as to the conditions of their employment. We are informed that a number of engineers went from the United States last season understanding that their living expenses were to be paid, and that after serving some months on the Isthmus they were notified that, after a certain date, they would be required to board themselves, or when living in camp at Government expense would have a certain sum deducted from their salaries. That this is substantially a correct statement would appear from a letter by Gen. Davis, of the Commission, printed in the "New York Times" of Feb. 27. The letter was addressed to the Commission, and related to the discontent among the employees, which he ascribed to the following causes:

> "The panicky feeling over the existence of yellow fever; asserted unfulfilled promises as to accommodations and allowances made by members of the commission, by its officers, or by its agents in the United States; the non-existence on the isthmus of amusements, diversions, and entertainments, always at hand at home; the existing high prices of commodities and of the necessaries of life; and homesickness."

As to yellow fever, Gen. Davis asserts that only four out of the 400 or 500 United States employees of the Commission have contracted yellow fever, and there has been only one death. Only three new cases have been reported on the Isthmus since Feb. 1. Concerning the promises above referred to, Gen. Davis is quoted as saying:

> The number of employees who have arrived on the Isthmus under appointments made in the United States who assert that they were told by members of the commission or by its employees in Washington that they all would have quarters or residences and excellent accommodations is so large and the assertions are so positive that I cannot but believe there is some basis for the statements made, and if any such assurances or promises were given it was a great mistake, I think.

So far as the discontent is due to such causes as that set forth in the paragraph just quoted, it is evidence of a serious defect in the management of affairs. At the present writing, the Panama Canal bill is still in the conference committee, and it cannot be told whether the House provision abolishing the Canal Commission will prevail or whether the Senate will succeed in continuing the present Commission in office. Whatever the termination may be, and whatever set of men is charged with the responsibility for the canal work after March 4, it is certainly to be hoped that the conditions of employment of the engineers at Panama may be made such as to make the force there contented and efficient, or at least satisfied that they have been fairly and justly treated by the Government to which they are rendering service.

A very remarkable railway accident in which a locomotive and a train of loaded 100,000 lb. ore cars jumped off the end of a high switchback and cleared a distance of over 300 ft. before striking the ground, is described in this issue. This is doubtless the record "long jump" for a railway train, and will match the most thrilling romances of imaginative story writers in which locomotives have been made to jump across the gap left by a missing bridge or trestle.

On its face, the accident would appear to have been a needless one. The runaway was caused, according to the statement furnished to us, by the sticking of the throttle valve on the locomotive. Of course the brakes would not hold the train on a 4 per cent. grade with the locomotive working steam; but one wonders why the reverse-lever was not used. By throwing it into mid-gear or a little back of the center the engineer should have been able to stop his train with the brakes. It hardly seems possible that both the throttle and reverse lever could have gone wrong at the same time. It is true that on heavy locomotives with slide-valves the reverse lever is hard to move when the engine is working steam; but the engineer and fireman together should certainly have been able to pull the lever back.

The accident gives a hint also, why a locating engineer always tries to end a switchback stub-end on a steep up-grade. To run out the end of a switchback on a high embankment may have been a necessity in this case, but such a location at the foot of a long, steep mountain grade is a standing menace whenever from any cause a train exceeds a given limit of speed down the grade.

The Simplon tunnel, 64,711 ft. or 12¼ miles long, broke through headings on the morning of Friday, February 24, 1905. The longest deep tunnel in the world, involved at its inception in many uncertainties and risks, and later in constant dangers and difficulties, it easily takes first place in the records of rock tunneling. It is a fourth longer than its nearest competitor among the railway tunnels of the Alps, the St. Gothard, and is also proportionately deeper; in difficulty it exceeds the other in, probably, a much greater ratio, and even the material advance in means and methods since 1880, the date of completion of the St. Gothard, leaves the Simplon much the more difficult. The longest rock tunnels elsewhere in the world sink into insignificance beside it. The construction of the Simplon tunnel is marked most prominently by a speed of advance utterly unprecedented in railway work. The best performances of the past in hard rock tunneling were doubled. When working at the best rate, a single heading in dense granitic rock was pushed forward by from 500 to nearly 700 ft. in a month! It is this rapid advance of headings that enabled the tunnel to be pierced through in six and one-half years, and would have enabled

even earlier completion but for repeated obstacles of the most serious kind.

Quite apart from speed of advance, there are enough notable features about the Simplon tunnel to make it memorable. There was boldness and courage in its very plan. Tunneling at best is wearisome, slow and risky, qualifications which increase in force with the length of tunnel, and in much greater ratio than the length. In the case of the Simplon, moreover, such a depth of rock lay above the line of the tunnel that extraordinary degrees of heat were certain to be met. Temperatures ten to fifteen degrees higher than any previously encountered in rock tunnel work were predicted, 115° F. as a maximum. Of the character and distribution of the strata to be pierced very little could be forecast; the surface outcrops were known, but the region is intricately folded and faulted, so that the estimates of their distribution on the line of the tunnel were pure guesswork. But it was fairly certain that much faulting, and probably many layers and pockets of crushed and disintegrated material would be met—not a pleasant outlook. It was certain, also, that the mass of material above the tunnel carried in its seams and passages an enormous amount of water, and that, as the ground water level lay high above the tunnel, this reservoir of water would be tapped under great pressure. When alternating hard and treacherous material, with large quantities of inflowing water under high pressure, are combined with a heat in which labor of any kind is almost impossible, rock tunneling may fairly be said to reach its ne plus ultra of difficulty and danger. More than one tunnel rests its fame on a single one of these conditions.

That the isolated mountain location of the tunnel complicated the problem may be readily conceived. We have already had the pleasure of describing* the very elaborate construction plant installed on the steep mountain sides at the tunnel portals. Conjoined with this plant, virtually part of the equipment, was a splendid organization of the working force and a highly systematic arrangement of working methods. It is these latter that are to be credited for the record-breaking rates of advance realized.

In the actual work of building the tunnel the difficulties which had threatened appeared in full extent. Rock strata of the most varied character were penetrated. At one time an extremely dense gneiss made typical hard-rock working possible, and the cycle of drilling, blasting and mucking went its rounds with military precision and extreme energy, giving maximum rate of advance; at another time great thicknesses of comminuted water-bearing material were encountered, in which the most careful work and the strongest timbering were hardly sufficient to maintain precarious progress. Great springs of water were tapped, taxing the abundant drainage provisions to the utmost. The temperature of rock and water, increasing constantly with increasing depth, required the full use of the elaborate ventilation and spraying plant. The predicted maximum temperature was reached, and passed, to the extreme heat of 130° F., fifteen degrees higher than that foretold in advance of construction. There was even promise of still higher temperature, and preparations were made for a great increase of the cooling equipment to cope with it; but, fortunately, it decreased from this point, and during the last year the temperature at the headings did not exceed 110° F.

Of the many incidents of difficulty which mark this history of the work, the last and, perhaps, most troublesome, may be recounted here. Nine months ago, when it seemed that the greatest difficulties of the work had been conquered, and that three or four months more would bring the headings together, a great hot spring was tapped in the north heading, flowing at the rate of over two million gallons per day. The excessive temperature of the water, and the difficulty of drainage (as the heading was already half a mile beyond the center, or 19 feet below the summit), caused the abandonment of work at this end. The heading was walled off by a bulkhead, to enable the full-section work and lining to continue behind, and all effort was concentrated on the south heading. Three months later, with but 800 feet of rock remaining to be penetrated, the south heading tapped a similar flow of hot water. After continued attempts to advance by hand drilling past the point of inflow, the heading was temporarily abandoned, and the heading of the parallel or secondary tunnel (the tunnel will ultimately comprise two parallel single-track tunnels, of which one only is built at present; but the heading of the second tunnel is carried along with the first for purposes of drainage, ventilation, and handling) was pushed forward. When abreast of the point of inflow into the main tunnel, a large flow was struck here also; but while the main tunnel at this point lay in dangerously fissured and fractured rock, the secondary heading could be advanced past the springs. Some distance beyond, a cross drift was made to the line of the main tunnel, and from here work could be resumed both forward and backward, for the final penetration. In this bypassing of the danger point three months were lost; but meantime the inflow of the hot spring had greatly decreased. The return heading to the abandoned face was successfully put through in January of the present year, the cross-drift having reached the axis of the main tunnel in the middle of December. The advance face also progressed at a good rate, so that at the end of January only 360 ft. of rock remained between the north and south bores. Progressing steadily at the rate of 15 ft. per day, the drills of February 24 pierced through the dividing wall into the abandoned water-filled north heading.

The work remaining to complete the tunnel for service is not mere routine, or clear of difficulty, but, nevertheless, it is quite subsidiary in importance. The Simplon tunnel is through. Switzerland and Italy, who supported the work, and the contractor who executed it, deserve the congratulations of the engineering world for the achievement.

*In Engineering News of Aug. 13, 1903, p. 134; Aug. 20, 1903, p. 154; and Aug. 27, 1903, p. 174.

We commend to every user of air compressors the valuable article in the present issue by Mr. A. M. Gow, relating to explosions in and about air compressors. That such explosions occur is known, we believe, to a comparatively small percentage of those who are responsible for the care and operation of air compressors; and very little has been known concerning the causes of these explosions or the precautions which should be taken to prevent them. With the exception of one or two brief papers before the Institute of Mining Engineers, which cautioned in a general way against too liberal lubrication of air compressors, we know of nothing whatever in technical literature upon this subject.

Mr. Gow's paper is the result of an extensive investigation undertaken for a large mining company whose president desired to ascertain what precautions should be taken to guard against accidents in the operation of his company's air compressors. Having completed the investigation, it was decided to make the report public for the benefit of engineers generally; and we may say in passing that it is a pity that more such reports of private investigations are not made public. Such papers as this of Mr. Gow's are a sort of contributions to technical literature for which there is always room. We propose to reprint it later in pamphlet form for the use of those who may desire to place it in the hands of the men in direct charge of air compressor engine rooms.

SOME HINTS ON RECORDING THE COST OF CONTRACT WORK.

There are certain principles that should be followed by any one who is keeping a record of the cost of contract work, if the greatest benefit is to be derived from such records. These principles are self evident to one who gives the subject serious consideration, but, that they are not self evident to the casual student of cost keeping, is made apparent by the fact that so few published records are wholly satisfactory. Therefore, we purpose enumerating some of the points that should be kept in mind by every contractor or engineer who is trying to secure cost data by his own observation.

To begin with, a memorandum should be made to accompany the cost record. This memorandum should give: First, a description of the weather, stating the percentage of rainy days, of freezing days, and all the climatic conditions affecting the progress of the work and its cost; second, a description of the locality in which the work is done, so as to give a picture of the surface conditions; third, a description of the general character of the workmen, the relation of supply to demand, the existence or non-existence of unions that limit output, etc.; fourth, a description of the character of the work itself, and especially of any uncommon features; fifth, a description of the methods of attacking the work, the plant used, and particularly a detailed statement of the organization of the forces.

It is not sufficient to enumerate the classes of workmen and their rates of wages, without stating how many of each class were employed and what their duties were. Thus, in timber work, we often see it stated that carpenters were paid $3 a day and laborers $1.50 a day, and that the cost of erecting the trestle was so and so many dollars per M. ft. B. M. Now, anyone who has erected trestles will have some idea of the probable proportion of carpenters to laborers engaged; but cost data are of greatest value to those who have little or no exact knowledge of the common organization of forces. For this reason the proportion of carpenters to laborers should be given, so that an itemized estimate may be made of the cost of each class of work per unit. Indeed, the farther the subdivision of cost is carried the better. If we are told that to erect a Howe truss bridge has cost $15 per M, we are certainly better off than if left to guess at the probable cost. But if we are told, in detail, the cost of hauling, the cost of framing, the cost of erecting falsework, and the cost of "swinging the bridge," we are enabled to make a far closer estimate of the probable cost of another bridge to be built under somewhat different conditions and at different rates of wages. The error that most contractors and engineers make is the error of lumping costs together. And, as a result, we hear it commonly stated that cost records are of little value except to the man who gathered them. Of lumped cost records this statement is true, but of properly kept records it is wholly misleading.

Following the subdivision of the labor items should come a sub-subdivision. Thus, in building a Howe truss we have the items of hauling the timber to the bridge site, the framing, etc. This hauling should be subdivided into the cost of loading, the cost of hauling per mile (size of load and condition of roads being stated), and the cost of unloading; for it is only by such an analysis that one can closely estimate the cost of hauling under different conditions. The work of timber framing should likewise be subdivided into classes. The chords, for example, require several times as much labor per M as is required to frame the braces. Rough timberwork may cost from 50 cts. to $15 per M, depending largely upon the character and amount of framing. A plank road, for example, may be laid for less than 50 cts. per M, after the delivery of the material and provided there is no sawing to be done. In every timber structure there are certain parts that cost far more per M than others to frame and erect; and the effort should be made to keep such records that the relative costs of different parts may be learned, not only with a view to predicting future costs, but with a view to reducing future costs by improving the design of the structure. Engineers are too apt to spend days studying how to reduce the amount of material required, as against minutes spent in keeping records that will show them how to reduce the labor of forming and erecting the structure.

Having stated the conditions, and having subdivided the work into its elementary cost items, a very common omission is the cost of erecting, shifting and dismantling the plant. Failure to segregate these items often leads to erroneous conclusions as to the unit cost of work. Thus, suppose it costs $20 to erect a derrick, and that

after its erection only 80 cu. yds. of masonry is laid with it. We then have a charge of 25 cts. per cu. yd. for plant erection alone. If this cost is lumped together with the labor of laying the masonry, and if the total is 85 cts. per cu. yd., we shall overestimate, by a large percentage, the cost of laying heavier masonry. On the contrary, failure to separate the expense of plant installation, on heavy work, leads to cost estimates that are altogether too low for light work. Therefore, wherever machinery is employed, the cost records should show the cost of erecting and dismantling it, separately from the cost of operating it.

Cost records that fail to give the rates of wages and the unit prices of materials are particularly exasperating, yet they are very common. Wage rates for the same class of work not only vary by large percentages in different cities, but they vary from year to year. Daily wages in the country are usually lower than in the city, and hours of labor are often longer. A cost record to be of permanent value should give the length of the working shift in hours, the number of shifts per day of 24 hours, and the rate of wages per hour. It should also state whether the work was done by contract or by company labor, for the efficiency of men working under a contractor usually ranges from 25% to 100% greater than the efficiency of men working by the day for a corporation. There are exceptions to this statement, but not many.

Finally, when it comes to making a permanent record of the cost of any job, eliminate repetitions and reduce all records to the cost per unit. Future work will be estimated by the unit, not by the lump sum. If the work is concrete locks, for example, do not record the cost by items per lock, but by items per cubic yard. The total yardage in the lock should be stated, the total cost per lock, and a brief summary including the lock gates and the like; but, if concrete is the main item, its cost should be recorded in terms of the unit commonly used in measuring concrete, namely, the cubic yard. The transactions of engineering societies furnish many examples of failure to reduce costs to the basis of the common units of measurement.

It is well to give the cost of a timber trestle per lineal foot; it is better to give it in terms of the unit used in buying and selling timber, namely, the M ft. B. M. All timberwork records should be kept in terms of this unit, including records of the cost of building of forms and falsework. Forms for concrete are generally given as costing so many cents per cubic yard of concrete; but, for purposes of comparison and for use in estimating the cost of concrete structures of different thicknesses, the cost of forms should be reduced to the M ft. B. M. as the unit. By failure to do this, many serious errors are made in estimating the cost of concrete work.

There are a few classes of work that are preferably recorded in units other than the common units of measurement, piling, for example. Piles are purchased by the lineal foot, and are usually paid for in terms of that unit; but the cost of pile-driving varies more closely with the pile than with its footage. As an average, we may say that it costs $1.25 to drive a pile for a foundation. If the pile is 50 ft. long it goes down easily, if it is 20 ft. long it goes down hard, and in each case the number of piles driven per day is apt to be about the same. The cost per foot is low in one case and high in the other, making it appear that the variation in the cost of driving a pile is far greater than it really is.

In publishing cost records many writers have followed the practice of Trautwine in stating the cost per unit in terms of the fraction of an hour or day. Instead of giving the cost of earthwork in cents, it is given in terms of the hundredth part of a day's work; or, what adds to the chances of error, in terms of wages assumed to be $1 per day of 10 hours. Now, one of the things that the inexperienced man does not know is precisely this thing that is omitted, namely, the rate of wages that each class of artisan usually receives. Furthermore, the ratio of supply to demand is often well shown by the rates of wages paid. Generally when the wages are above normal, the demand is greater than the supply, and the workmen are correspondingly inefficient, because each man knows that he can quickly pick up another job if he is discharged. The rise and fall of wages, extending over a period of years, is itself subject matter for study; hence if all records were reduced to a basis of $1 per day, we should lose much information of value to the student of engineering economics. Finally, it is very deceiving to record carpenter labor at $1 a day alongside of common labor at the same price.

There is but one good end attained by using one unit of wages, or by using the working day itself as the unit, and that is the ease of comparison of labor costs where wages differ. However, such comparison is usually possible by merely employing a little mental arithmetic. If wages are $1.25 in one case and $1.50 in another, we can add 20% to the cost records in the first case, thus putting both prices of work on the same basis. We conclude, therefore, that the advantage of using one wage unit is slight at best, and the disadvantages far more than offset the gain.

Cost records kept as above indicated possess value not only for him who has gathered them, but for any one else who is privileged to study them. Cost records are most commonly pronounced valueless by the man who has failed to learn their value through failure to keep them properly. Cost analysis can be made quite as much of a science as any other branch of engineering, and it is indeed to be regretted that this fact has not been more clearly recognized in the past.

LETTERS TO THE EDITOR.

Destruction of Concrete by Alternate Freezing and Thawing Between Tide Levels.

Sir: In Engineering News of Oct. 20, 1904, J. W. Stadley, of North Bay, Ontario, says:

> Concrete in railway structures, especially in northern latitudes where exposed to great variations of temperature, alternate freezing and thawing, contracting and expanding, must be regarded as entirely experimental.

To the above, I would add that in piers, abutments, and dock walls between high and low water mark in ocean tidal waters, concrete surfaces are not proving satisfactory in places where exposed to alternate freezing and thawing between tides in winter and to wet and dry conditions between tides in summer. Yours truly,

Wm. B. MacKenzie,
Chief Engineer Intercolonial Ry. of Canada.

Moncton, N. B., Feb. 6, 1905.

An Accident to a Plunger Elevator.

Sir: I quote the following from a Providence, R. I. paper of Feb. 7:

> A SHOWER AT SHEPARD'S.
> Embroidery Stock Damaged Yesterday.
>
> Luckily there were but comparatively few people shopping in the Shepard Company's store about 2 o'clock yesterday afternoon, because at that time a deluge of water came from the basement, where the elevator plungers come through the floor. This water struck the ceiling of the main floor and rained down on a portion of their stock of embroideries, giving them a soaking. It is a good thing for the store that this did not happen in the vicinity of the silks and dress goods stocks.
>
> The water was quickly shut off and soon everything was going as usual in the store.

Recently there have appeared in nearly all of the daily and technical papers, advertising and reading matter to the effect that the plunger elevator is not heir to any weaknesses at all and that it is absolutely safe. It would seem from the above quotation that there is at least one weak point. The water which was forced out of the cylinder with such force that it struck the ceiling of the main floor undoubtedly came from an opening, probably the result of defective packing, or possibly from a break in the valve. This water, coming from the cylinder, must, of necessity, have allowed the car to descend at a speed depending on the rate of discharge of the water from the break. The same thing would happen should the cylinder itself break at any point.

Will you be good enough to let us know what provision is made with plunger elevator plants to avoid accidents due to such an occurrence? The advertisements state that no car-safety device is required. If not, what is to prevent the car from falling?

New York, Feb. 8, 1905. Reader.

(In accordance with our usual custom, proof of the above letter was submitted to the Plunger Elevator Co., with an invitation to present a reply. We append the letter received from them as follows.—Ed.)

Sir: We wish to thank you for the courteous opportunity offered us to reply to an inquiry in regard to Plunger Elevators, made by one of your readers with special reference to an occurrence at Shepard Store, Providence, R. I.

After carefully reading over the article to which the reader refers, we found that there are not enough details given for us to formulate an opinion as to the cause of the trouble. Yours truly,

The Plunger Elevator Company.

New York, Feb. 21, 1905.

Experience with Impure Sand for Concrete.

Sir: I was much interested in the article on the use of impure sand for concrete by Mr. J. C. Hain, in your issue of Feb. 2. During an experience of six years in charge of masonry work as engineer, and of four years as a masonry contractor, I have had to deal with many kinds and conditions of sand and have made as thorough a study of each as limited facilities for testing would permit. Several years ago on one contract, I was obliged to resort to grinding sandstone to obtain sand, and found the product to contain much very fine dust, so fine, indeed, that it was smooth as flour to the touch. I discovered by a series of tests that, when mixed in the proportion of three parts sand to one part cement, the product as it came from the grinding pan made a stronger mortar by 10% than was made from the same product after the dust had been removed by washing. On the other hand, when mixed in the proportion of two parts sand to one part cement the washed sand made the stronger mortar. I later found that by mixing limestone "crusher dust" with washed river sand, a better result was obtained than with the washed sand alone. I have also found the same to apply when clay is mixed with clean sand and also when loam is the impurity, but always with a mixture of three parts sand to one cement.

In trying to explain this apparent explosion of the time-honored theory of "clean, sharp, coarse sand," to myself, I followed a course of reasoning and found a conclusion which though simple may be of interest to some of your readers. If in making mortar the proportions of sand and cement are not such that the voids between the particles of cement are entirely filled then some of the particles are bound together tightly while others must be entirely loose leaving a "weak link in the chain." Now, if some diluting substance were mixed with the cement, in just the proportion to make a mixture which would fill all the voids in the sand, then the particles would all be bound together and in the same way, thus making the links in our chain all of the same strength. If this theory is correct, then in order to obtain the best possible result from any given portion of cement, we must supply some substance to bear the same relation to the coarse sand and the cement in the mortar, which sand itself bears to the crushed stone and the cement in concrete, and in just the proportion to fill the voids and no more. This must of course be some very fine substance, the nature of which does not allow a chemical combination with the cement, such as was supplied by the "crusher dust," the clay and the loam in the above cases.

It would, therefore, seem that the only test necessary for sand containing any of the above impurities is to determine whether the volume is increased by adding the desired amount of cement and thus the voids be more than filled. This can readily be done in the field with a sample bottle full of the sand in question. One can also determine by adding all the cement the sand will take up without increasing the volume, about how much diluting material should be added to obtain the best result. I may say that I have held to this theory for some years, have put it to the test several times and have never found reason to think it unsound.

Very respectfully, Charles C. Huestis,
Assoc. Mem. Am. Soc. C. E.

118 Norwood Ave., Buffalo, N. Y., Feb. 14, 1905.

A Short Method for Computing Deck Plate Girder Railway Bridges.

Sir: The following presents a short method for computing bending moments and shears in deck plate girder railway bridges, using a uniform dead load, a uniform live load, and a concentrated excess live load, in combination.

First divide the span (between centers of bearings) into ten equal parts, numbering the points 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, as shown on the accompanying diagram.

To compute the bending moment: It is known that the limiting curve for the bending moments for all three kinds of loading, and hence for their combination, is a parabola with the vertex at the center. To construct the curve write

$$0,\ 1,\ 2,\ 3,\ 4,\ 5,$$

and immediately under

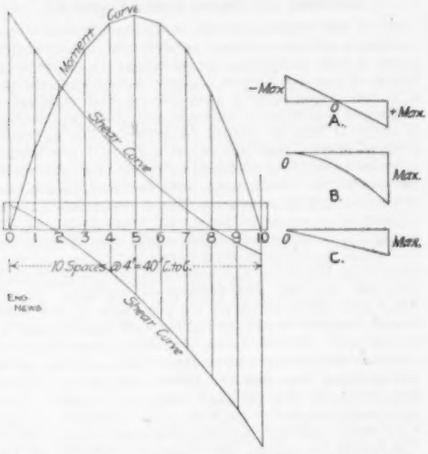
$$10,\ 9,\ 8,\ 7,\ 6,\ 5,$$

Then multiplying each figure in the upper row by the one beneath and dividing by 25 gives the series of coefficients

$$0,\ \frac{9}{25},\ \frac{16}{25},\ \frac{21}{25},\ \frac{24}{25},\ \frac{25}{25},$$

under the points 0, 1, 2, 3, 4, 5, respectively. If M_5 is the maximum moment due to the given loading at the center

of the span, then: $M_4 = \frac{24}{25} \times M_5$; $M_3 = \frac{21}{25} \times M_5$; $M_2 = \frac{16}{25} \times M_5$; $M_1 = \frac{9}{25} \times M_5$; $M_0 = 0$; and of course corresponding values in the other half span. The moment at the center can be readily found for the different loadings, and by simple multiplication the moments at the points 1, 2, 3, 4, etc., are found and plotted as shown on the diagram.



Shear and Moment Diagrams for Plate Girder Railway Bridges for Uniform Dead Load, Uniform Live Load, and Single Concentrated Live Load.

To find the shears: The dead load shear varies as a straight line, being a positive maximum at one end, zero at the center, and a negative maximum at the other end of the span, as at A in the figure. The uniform live load shear varies as a parabola, maximum at one end and zero at the other.

The ordinates of this parabola may be found by writing the figures thus:

0 1 2 3 4 5 6 7 8 9 10
0 1 2 3 4 5 6 7 8 9 10

Then multiplying each figure by the one below and dividing by 100, the ordinate coefficients are obtained thus: 0, 0.01, 0.04, 0.09, 0.16, 0.25, 0.36, 0.49, 0.64, 0.81, 1.00. The concentrated live load shear varies as a straight line, being a maximum at one end and zero at the other. Now we must combine these three figures into our shear curve so as to read the total shear at any of the points. Since the dead load shear becomes zero at the center, the shear at any point will be 1-5 less than at the preceeding point, and for the uniform live load the decrease will be 1-10.

Hence we can make the following:

TABLE OF SHEAR COEFFICIENTS.

Points.	0	1	2	3	4	5	6	7	8	9	10
D.L. shear.....	Max.	—.2	—.4	—.6	—.8	0	+.2	+.4	+.6	+.8	Max.
U.L.L. "	"	.81	.64	.49	.36	.25	.16	.09	.04	.01	0
C.L.L. "	"	—.1	—.2	—.3	—.4	—.5	—.6	—.7	—.8	—.9	0

EXAMPLE.—Assume a bridge:
40 ft. c. to c. of bearings.
Dead load, 500 lbs. per lin. ft. per girder.
Uniform live load, 2,500 lbs. per lin. ft. per girder.
Concentrated live load, 25,000 lbs. per girder.

M_5 = D L mon = 500 × 40² ÷ 8 = 100,000 ft.-lbs.
U L L " = 2,500 × 40² ÷ 8 = 500,000 " "
C L L " = 25,000 × 40 ÷ 4 = 250,000 " "
M_5 = 850,000 " "

850,000 ÷ 25 = 34,000 ft.-lbs.
M_4 = 34,000 × 24 = 816,000 ft.-lbs.
M_3 = 34,000 × 21 = 714,000 " "
M_2 = 34,000 × 16 = 544,000 " "
M_1 = 34,000 × 9 = 306,000 " "
M_0 = 0

These moments are then plotted on the diagram.

SHEAR TABLE.

Points.	0	1	2	3	4	5	6	7	8	9	10
D. L.....	10,000	8,000	6,000	4,000	2,000	0	—2,000	—4,000	—6,000	—8,000	—10,000
U. L. L...	50,000	40,500	32,000	24,500	18,000	12,500	8,000	4,500	2,000	500	0
C. L. L ...	25,000	22,500	20,000	17,500	15,000	12,500	10,000	7,500	5,000	2,500	0
Totals..	85,000	71,000	58,000	46,000	35,000	25,000	16,000	8,000	1,000	5,000	10,000

These shears are then plotted on the diagram in both directions if desired.

Paul Alexander Blackwell,
Jun. Am. Soc. C. E.
Canonsburg, Pa., Feb. 3, 1905.

Notes and Queries.

Mr. F. W. Scarborough, Engineer of Maintenance of Way, Chesapeake & Ohio Ry., calls attention to our statement, in our issue of Feb. 23, 1905, that the Baltimore & Ohio R. R. Co. has the largest pier on the Atlantic Seaboard, 800 × 129 ft., at its Baltimore water-front terminal. He informs us that Piers 5, 4, 6 and 8 of the Chesapeake & Ohio Ry. at Newport News, Va., are respectively 790 × 167 ft., 654 × 160 ft., 710 × 170 ft., and 869 × 194 ft., all of which exceed in area the above-noted B. & O. pier. Evidently C. & O. Pier 8 is not only the longest, but also the largest of the group, its deck area of 156,800 sq. ft. exceeding the area of the B. & O. pier by 54%, while C. & O. Piers 5, 4 and 6 exceed the B. & O. pier by 30%, 3%, and 19%, respectively.

A contractor asks the following question: Is it customary, in computing earthwork to make an allowance for the "swell" caused by the driving of piles which force the ground between them above the excavation grade? The grading was completed before driving the piles, and was to be paid for by the cubic yard of excavation. The specifications do not cover this point.

We submit the question to our readers.

"Chief Draftsman," El Paso, Tex., inquires which is the better practice in lettering a railway alinement map: (1) To place the lettering to read from the direction from which the line is running, so that as one follows along the line and turns the sheet, the lettering will be read directly; or (2) To make all the lettering so as to read from either the bottom or right-hand side of the sheet as is done with an ordinary drawing?

Our preference would be for the second plan, unless some use is to be made of the map which will make lettering placed in the other way more easy to read.

B. W. S., of Wallace, Idaho, asks (1) what are the standard gages of railways in Great Britain, Germany, France and Russia; and (2) how did such an odd figure as 4 ft. 8½ ins. happen to be adopted in the United States:

1. The standard gage of England, Scotland, France and Germany (and practically throughout Europe) is 4 ft. 8½ ins.; Ireland, 5 ft. 3 ins.; Russia, 5 ft., and Spain, 5 ft. 6 ins.

2. The origin of the 4-ft. 8½-in. width of gage is not definitely known; it existed on the old colliery "tramways" in England long before the days of railways. It has been stated that the old tramways with L-shaped rails (outside flanges) for flangeless wheels were 5 ft. over the rails, and that when flanged wheels were introduced they were made to fit the gage between the inner edges of the rails, which happened to be 4 ft. 8½ ins. George Stephenson worked among these tramways and when he began to build railways he adopted the gage with which he was familiar. Other gages were adopted, however, but with the growth of the railway system the necessity of a uniform gage became apparent and a British government inquiry in 1846 showed the superiority of the 4-ft. 8½-in. gage that it was generally adopted as the standard. English practice in this respect was naturally followed in this country, but various gages from 3 ft. to 5 ft. have been extensively used here at different times. The trouble and expense due to break of gage, however, have led to the conversion of thousands of miles of track to the "standard" 4 ft. 8½ ins.

THE COST OF CONCRETE DEPOSITED IN MOLDS UNDER WATER FOR A PIER AT SUPERIOR ENTRY, WIS.

The methods and cost of building the concrete south pier, 3,023 ft. long, at Superior Entry, Wisconsin, are described in Vol. 8, Part 4, of the report of the Chief of Engineers, U. S. A., from which we have abstracted the following:

About 80% of the concrete was deposited in molds under water, according to a plan submitted in 1902 by Major D. D. Gaillard, Corps of Engineers. The molds consisted of bottomless boxes, built in four pieces, two sides, and two end pieces, held together by 1¼-in. turnbuckle tierods. Cast-iron weights were attached to the molds to overcome the buoyancy of the timber.

Fig. 1 shows a typical cross-section of the pier, and Fig. 2 shows a plan of about two-thirds its length. The serial numbers in Fig. 2 indicate the successive blocks of concrete. The concrete was built in place, in two tiers of blocks, the lower tier resting directly on piles and entirely under water. The upper tier of blocks was almost entirely above water. A pile trestle was built on each side of the proposed pier, as shown in Fig. 1, and a traveler, for raising and lowering the molds, spanned the gap between the two trestles, Fig. 4. After the mold for a block of concrete had been placed on the bottom, it was filled with concrete lowered in a bucket, Fig. 3, with a drop bottom. Twelve of these buckets were used, and were hauled from the mixer on cars to a locomotive crane, Fig. 4, which lifted each bucket from the car and lowered it to place. It will be noted, Fig. 4, that the locomotive crane was elevated on a gantry frame so that a train of cars on the same trestle could pass directly under it, without interference. This enabled two of these locomotive cranes to work on the same trestle.

Each concrete bucket was provided with two 12 oz. canvas curtains or covers, each 3 × 4 ft., quilted with 110 pieces of 1-16 × 1 × 3-in. pieces of sheet-lead. The curtains were fastened, one to each side of the top of the bucket, and were folded over the concrete so as to cover it completely and protect it from wash while being lowered through the water. Occasionally, when an opportunity has occurred to allow the top of the concrete in a bucket to be examined after being lowered and raised through 23 ft. of water, the concrete has invariably been found in good condition. Discoloration of the water from cement has seldom been noticed during the descent of the bucket. The concrete for this subaqueous work was mixed quite wet. It should be added that the concrete bucket is tripped by a latch, Fig. 3, by means of a rope leading to the derrick man on the locomotive crane.

The pebbles for the concrete were delivered by contract, and were unloaded from the scows by means of a clam-shell bucket into a hopper. This hopper fed the pebbles on to an endless belt conveyor, which delivered them to a rotary screen. Inside this screen water was discharged under a pressure of 600 lbs. per sq. in. from a 4-in. pipe, to wash the pebbles. From the screen the pebbles passed through a chute into 4-yd. cars, which were hauled up an incline to a height of 65 ft., by means of a hoisting engine. The cars were dumped automatically, forming a stock pile. Under the stock pile was a double gallery or tunnel, provided with eight chutes through the roof, and from these chutes the cars were loaded and hauled by a hoisting engine up an inclined trestle to the bins above the concrete mixer. A system of electric bell signals was used in handling these cars. The sand was handled from the stock pile in the same manner. The cement was loaded in bags on a car at the warehouse, hauled to the mixer, and elevated by a sprocket chain elevator.

Chutes from the bins delivered the materials into the concrete mixer, which was of the modified cubical type, revolving on trunnions about an axial line through diagonal corners of the cube. The mixer possessed the advantage of charging and discharging without stopping. It was driven by a 7 × 10-in. vertical single engine with boiler. The mixer demonstrated its ability to turn out a batch of perfectly mixed concrete every 1½ mins. It discharged into a hopper, provided with a cut-off chute, which discharged into the concrete buckets on the cars. Four buckets of concrete were hauled in a train by a locomotive to their destination. There were two locomotives and 23 cars.

In the operation of this plant 55 men were employed, 43 being engaged on actual concrete work and 12 building molds and appliances for future work. The work was done by day labor for the Government, and the cost of operation was as follows for one typical week, when, in 6 days of 8 hours each, the output was 1,383 cu. yds., or an average of 230 cu. yds. per day. The output on one day was considerably below the average, on account of an accident to plant, but this may be considered as typical:

	Per cu. yd.
Pebbles from Stock Pile to Mixer:	
4 laborers at $2.....	$0.0348
1 engineman at $3.....	0.0131
Coal, oil and waste at $1.03.....	0.0043
Sand from Stock-Pile to Mixer:	
5 laborers at $2.....	0.0434
1 engineman at $2.50.....	0.0109
Coal, oil and waste at $0.82.....	0.0035
Cement from Warehouse to Mixer:	
5 laborers at $2.....	0.0434
Mixing Concrete:	
1 engineman at $2.50.....	0.0109
1 mechanic at $2.50.....	0.0108
Coal, oil and waste at $1.29.....	0.0056
Transporting Concrete:	
4 laborers at $2.....	0.0348
1 engineman at $3.....	0.0130
Coal, oil and waste at $0.66.....	0.0028

Depositing Concrete in Molds:	
4 laborers at $2	0.0348
1 engineman at $3	0.0130
1 rigger at $3	0.0130
Coal, oil and waste at $1.18	0.0051
Assembling, Transporting, Setting and Removing Molds:	
4 laborers at $2	0.0347
1 engineman at $3.25	0.0141
1 carpenter at $3	0.0130
1 mechanic at $2.50	0.0109
Coal, oil and waste at $1.39	0.0060

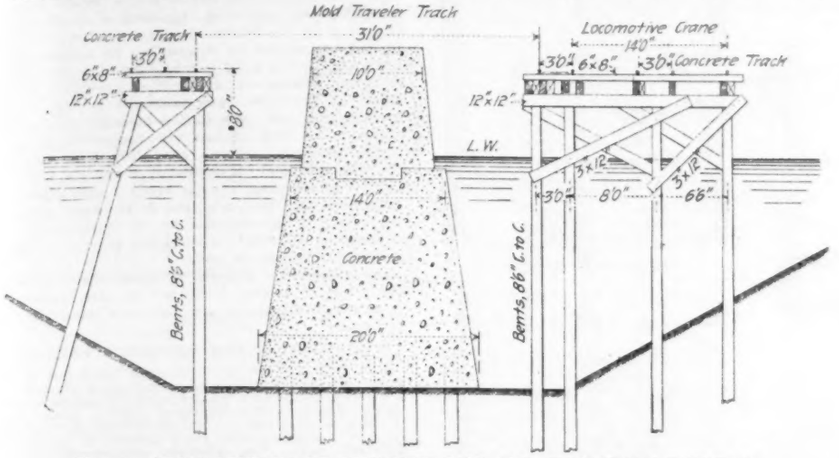


FIG. 1. CROSS-SECTION OF CONCRETE PIER AND TEMPORARY TRESTLES.

Care of Tracks:	
1 laborer at $2	0.0086
1 mechanic at $2.50	0.0109
Supplying Coal:	
3 laborers at $2	0.0260
Blacksmith Work:	
1 laborer at $2	0.0086
1 blacksmith at $3.25	0.0141
Water Boy at $0.75	0.0032
Total, per cu. yd.	$0.4473
Add 75% of the cost of administration	0.1388
Total labor, per cu. yd.	$0.5861

The total cost of each cubic yard of concrete in place is estimated to be a follows:

	Per cu. yd.
Ten-elevenths cu. yds. pebbles, at $1.085	$0.9864
Ten-twenty-seconds cu. yd. sand, at 0.00	0.0000
1.26 bbls. cement, at $1.77	2.2302
Labor, as above given	0.5861
Cost of plant distributed over total yardage	0.8400
Total	$4.6427

the completion of both piers. It is said, however, that 80% is too high an allowance for the probable depreciation. Bearing upon the reason for doing this work by day labor, we quote from the report as follows:

Under formal proposals for building in place the concrete south pier, in response to due advertisement the lowest bid received was that of the Lake Superior Contracting and Dredging Company for $7.44 per cu. yd. of concrete in place. This bid contemplated the furnishing of the sand and cement by the United States. The sand having been deposited under other contracts for dredging, will not be included in the following estimate. The average cost per cubic yard to the United States for the cement required for the south pier has been shown to be $2.2302. The United States would have been responsible for the storage of this cement, the cost of which is shown by dividing the amount expended in building warehouse, dredging slip, and building wharf, by the total number of cubic yards of concrete required for the south pier.

Thus $\frac{\$4,444.21}{42,540.79} = \$0.1045$ for each yard of concrete.

Hence: $2.2302 + $0.1045 + $7.44 = $9.7747, which is the equivalent of the lowest bid received for this work, or an excess of $5.13 per cu. yd. of concrete in place over the present cost, as shown by the foregoing illustration, when performed with United States plant and hired labor. As a further illustration of the difference in cost with United States plant and hired labor as against the lowest bid for performing this work, it can be stated that the total amount of concrete molded in place for the month of June is 4,537.62 cu. yds., and 4,537.62 × $5.13 = $23,277.90, which represents the economy to the United States in this work for the month of June, 1904, as compared with the lowest bid of $9.775 per cu. yd.

It is very gratifying to be able to report that the entire plant for performing this work has at this date been proved in actual practice, and notwithstanding much of it is of entirely original and novel design, it has worked in a most satisfactory manner. The question of handling, placing, and removing the large subaqueous molds without the aid of submarine divers has been most satisfactorily solved by the special devices designed for accomplishing the work.

It is only fair to add that no contractor bidding on one pier could have been certain of securing the other; therefore he could not do as the Government officials have done in making the above distribution of plant cost—namely, distribute the cost of the plant over two piers. Furthermore, it is not stated how much the pile trestles cost per cubic yard of concrete. Yet the trestles were as much a part of the cost of placing the concrete as the plant itself. The magnitude of this subaqueous concreting, and novelty of the plan of doing it, probably deterred contractors from bidding low; but, whatever the reason for the extremely high bids submitted, the cost data above given should prove most instructive to contractors as well as to engineers.

The proportions of the subaqueous concrete were 1 : 2.5 : 5 by volume, or 1 : 2.73 : 5.78 by weight, cement being assumed to weigh 100 lbs. per cu. ft. The proportions of the superaqueous concrete were 1 : 3.12 : 6.25 by volume, or 1 : 3.41 : 7.22 by weight. The dry sand weighed 109.2 lbs. per cu. ft., the voids being 35.1%. The pebbles weighed 115.5 lbs. per cu. ft., the voids being 31%.

THE MOLDS.—As above stated, the molds were bottomless boxes built in four pieces, two sides and two ends, held together by tie-rods. Fig. 5 shows an end and a side of one of the shallow water molds. Fig. 6 shows in detail the method of fastening the end to the side. It will be seen that the 1¼-in. turnbuckle tie-rods pass through the ends of beams that bear against the outside of the mold. These tie-rods have eyes at each end, in which rods with wedge-shaped ends are inserted. The mold is erected on the trestle by the locomotive crane, and is then lifted by the mold traveler, Fig. 4, carried and lowered to place. The largest one of these molds, with its cast-iron ballast, weighs 40 tons. When it is desired to remove a mold, after the concrete block has hardened, the nuts on the wedge-ended rods are turned, thus pulling the wedge end from the eye of the tie-rod, and releasing the sides of the mold from the ends. The locomotive crane then raises the sides and ends separately, and assembles them ready to be lowered again for the next block. The time required to remove one of these 40-ton molds, reassemble and set it again, rarely exceeds 60 mins., and has been accomplished in 45 mins.

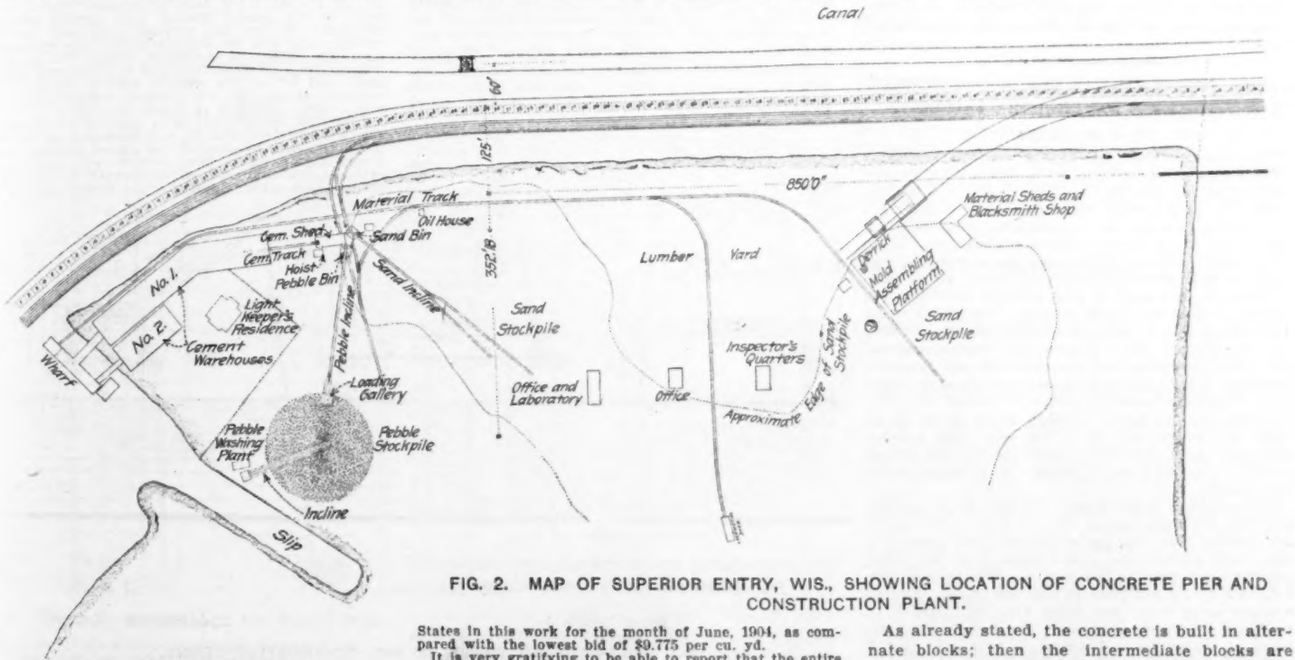


FIG. 2. MAP OF SUPERIOR ENTRY, WIS., SHOWING LOCATION OF CONCRETE PIER AND CONSTRUCTION PLANT.

It will be noticed that the sand cost nothing, as it was dredged from the trench in which the pier was built, and paid for as dredging. The cost of the plant is distributed over this South Pier work and over the proposed North Pier work, on the basis of only 20% salvage value after

As already stated, the concrete is built in alternate blocks; then the intermediate blocks are built, the ends of the concrete blocks just built serving as end molds for the new blocks. The two sides of a mold (without the end pieces) are assembled by the aid of templates, and are bolted together by the tie-rods shown in Fig. 7. To hold the sides apart when the templates are removed, it is necessary to surround each of the six tie-rods

with a box of 1-in. plank. These boxes measure 4 ins. square on the inside, and are left buried in the concrete. Their purpose is to act as horizontal struts to hold the sides of the mold apart, and to permit removal of the tie-rods after the concrete block has been built. The removal of these rods is accomplished by withdrawing the wedge-ended rods.

The mold traveler, Fig. 4, deserves a brief description. It is provided with a four-drum engine, and the drums are actuated by a worm gear, which is positive in its movement in lowering as well as in raising. The drums act independently or together, as desired. The hoisting speed is 6 ft. per min., and the traveling speed, 100 ft. per min. The load is suspended on four hooks, depending by double blocks and ⅝-in. wire ropes from four trolleys suspended from the truss, which allows lateral adjustment of the mold. The difficulty of using so broad a gage as 31 ft., on a curve having a radius of 563 ft., has been overcome by using a differential gear in the driving shaft of the propelling gear, thus compensating for the greater distance traveled by the wheels on the outer rail. The whole machine is carried on six trucks, having two double-flanged wheels each. The four forward trucks are swiveled on steel bed plates, with 3-in. king bolts. The two rear trucks are fixed to the chord, and have idler wheels, which slide on their axles so as to accommodate themselves to the curve.

In closing, it should be stated, that the plans for this work, which is now about half completed, were prepared, under the direction of Major D. D Gaillard, by Mr. Clarence Coleman, U. S. Assistant Engineer, and Mr. M. W. Lewis, Junior Engineer.

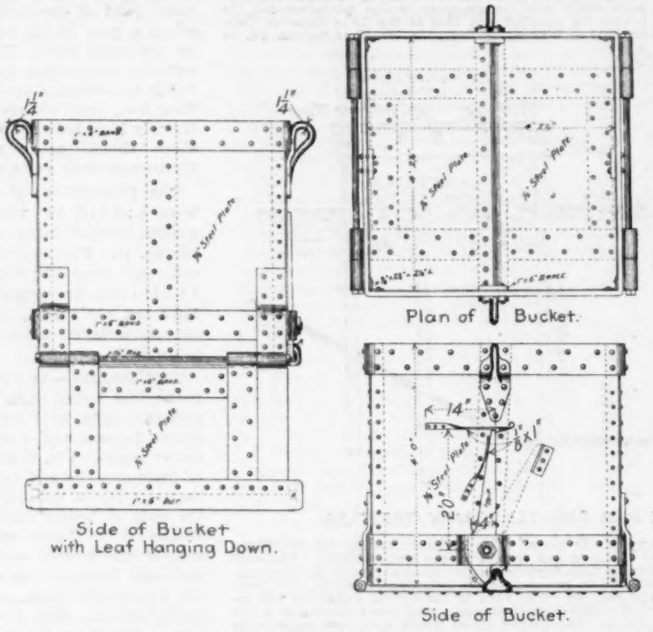


FIG. 3. BOTTOM DUMP BUCKET USED IN DEPOSITING CONCRETE UNDER WATER.

LAYING STREET RAILWAY TRACKS IN CINCINNATI: SPECIFICATIONS FOR BITULITHIC PAVEMENT.*

By J. M. Harper.†

The purpose of this paper is to give a brief description of the concrete construction of a double track railway on one of the principal crosstown lines; also a brief description of a peculiar construction for a double track line leading from the city through some of the suburban villages on a very heavily traveled thoroughfare.

The line first mentioned connects the eastern hill tops with the base of the western hills, cutting across some 15 miles of connecting at each terminal with lines extending to suburban points beyond. The grades where the concrete girders were laid are steep, maximum 5.83%, and the distance about ¾-mile. The original material with which the street had been improved was limestone macadam, and it had become so out of repair as to render travel dangerous either by vehicle or trolley car. The rail used was the Lorain "Trilby" girder section 60 ft. long, 109 lbs. per yd., and 9 ins. deep. The trenches were taken out 18 ins. below grade, and the rails cribbed up so as to permit 9 ins. of concrete to be tamped under base of rail.

The girder was 18 ins. wide at the base, 16 ins. on top, and 15½ ins. high, leaving 2½ ins. between the top of the concrete girder and top of the rail. This space was filled with asphalt, the entire roadway of the street proper being paved with this material. Ties 6x8 ins., and 8 ft. long were placed every 12 feet, and tie rods were introduced every 6 ft. The forms were held together at the top by U-shaped iron bands. The concrete was composed of 1 part Portland cement, 3 parts sand, and 5 parts stone crushed to the usual size and unscreened.

The concrete was permitted to set for ten days, traffic being switched from one track to the other of incompleted to completed sections by temporary portable crossovers. This construction has been carrying the travel for some seven months and no breaks in the pavement next the rails or at other places have occurred, except at one point where for some 60 ft. under one rail it exhibits small openings. It is supposed that here the girder has settled and fractured due to the presence of springs that failed to develop during the progress of the work. The cost of this double track construction, exclusive of rails and ties, was $3 per lin. ft.

On the highway leading out to several northeastern villages, the pavement is of granite, on the usual concrete foundation. This work is being performed by the County Commissioners under a general law and a tax levy, the specifications being prepared, contract let and the work done under direction of Mr. Frank S. Krug, the County Engineer. The street railway company was desirous of using the same rail section described above. But as it would be a year before the steel could be delivered, the engineer refused to wait, and the company was compelled to lay whatever sections it could pick up. Where shallow rail was used, in order to provide sufficient depth for the granite blocks, seasoned oak strips were placed upon top of the ties, the later being 6x8 ins., 8 ft. long, spaced 2 ft. c. to c., sometimes more. These strips were immersed in hot creosote oil and then coated with tar. The granite blocks stand flush with the top of the rail and a space 1¼ ins. wide was left between the side of the rail and the granite block. This opening extends down to the concrete foundation and is filled with pebbles ranging in size from a pea to a hazelnut; the voids are completely filled with Portland cement grout. Not less than seven days must elapse before traffic is permitted on any part of the completed line. A certain portion of the tracks (it is a double line) have been operated over now for six months and no breaks or openings next the rails have developed. I am of the opinion, however, that this condition is due almost wholly to the very severe and rigid inspection to which the material and workmanship was subjected.

During the past two years the asphalt streets of Cincinnati have deteriorated to a marked extent. The mayor, who is an automobolist and horseman, besides being of progressive characteristics, organized a single handed crusade in the city boards. During the course of his fight for better conditions he insisted that the bitulithic pavement was the best fitted to meet Cincinnati conditions as to grades, travel and drainage. A committee of the Board of Legislation was instructed to visit several municipalities, and their finding bordered upon the enthusiastic in favor of this new combination of street paving materials. Shortly after they made their report the machinery of legislation under the new code was set in operation, and the result is that resolutions, ordinances etc., will culminate in the early spring in the letting of the contracts for the improvement with bitulithic of 30 streets, aggregating 12 miles in length and 238,772 sq. yds. in area.

The specifications prepared for these improvements are the result of a very great deal of care, particularly from a legal standpoint, and may be of interest and information:

SPECIFICATIONS FOR BITULITHIC PAVEMENT.

EARTH FOUNDATION.—The earth foundation or subgrade will be brought to an even surface, parallel with the grade proposed for the pavement, by making the necessary excavation or embankment. Soft or spongy earth or other material not firm, will be removed, and the space filled with stone, or with extra concrete, as specified for pavement base. The subgrade surface will be compacted by rolling and ramming. Any portion not accessible to the roller shall be thoroughly compacted by ramming. When this shall have been done, the surface shall be true, smooth, and 8 ins. below the finished surface for the pavement. Excavation shall be paid for at the price bid per cubic yard, and crushed stone, or concrete, per cubic yard, at the price bid for same. All excavated material shall belong to the contractor.

PAVEMENT BASE.—Upon the earth foundation prepared as specified shall be laid a layer of crushed granite bolders or hard limestone, that after its ultimate compression by rolling and ramming shall have a depth of 6 ins. The surface of the layer of stone will be true, exactly parallel with and 2 ins. below the surface proposed for the finished pavement. The crushed stone shall be sound and clean, the fragments being uniformly graded in sizes from material that will pass a 3-in. screen to material that will stand on a 1-in. screen, and the various sizes shall be laid in strata, each stratum passing through a screen having a diameter not to exceed 1 in. larger than the diameter of the screen through which the stone refuses to pass.

The layer of crushed stone prepared as specified will be coated with Warren's No. 1 Puritan brand semi-liquid composition, or material of the same chemical and physical properties, said bitumen to be sufficiently flexible to unite freely with the cold stone. On top of this composition shall be spread a heavy coating of Warren's No. 24 Puritan brand hard bituminous cement, or material of the same chemical and physical properties, thoroughly binding the pavement base and making it readily unite with the bituminous concrete wearing surface. One gallon of bituminous cement will be used to each square yard of surface. On this prepared pavement base shall be laid the wearing surface, which shall be composed of carefully selected hard crushed stone, mixed with bitumen and laid as herein specified.

WEARING SURFACE.—After heating the stone in a rotary mechanical drier to a temperature not to exceed 250° F. it shall be elevated and passed through a rotary screen having six or more sections with varying sized openings, the maximum of which shall be 1¾ ins. and the minimum 0.1-in. diameter. The several sizes of stone thus separated by the screen sections shall pass into a bin containing six sections or compartments. From this bin the stone shall be drawn into a weigh-box resting on a scale having seven beams. The stone from each bin shall be accurately weighed in the proportion which has been previously determined by laboratory tests to give the best results—that is, the most dense mixture of mineral aggregate, and one having inherent stability. From the weight-box each batch of mineral aggregate, composed of,

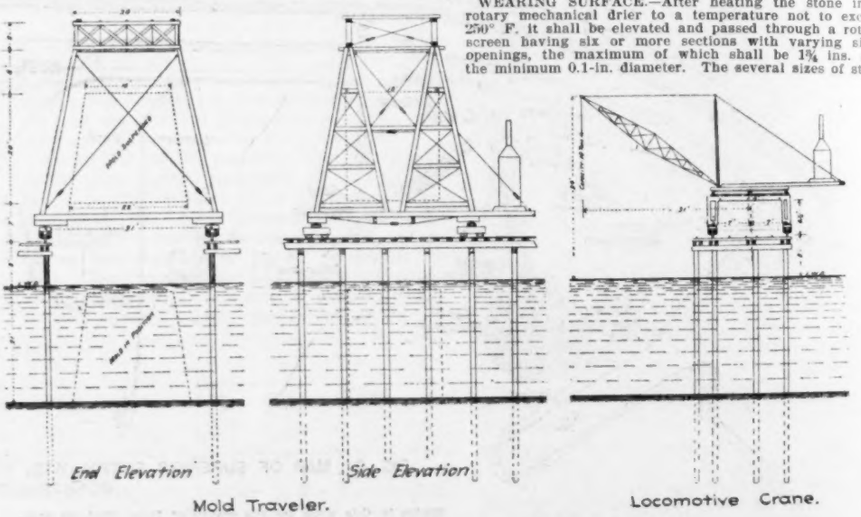


FIG. 4. MOLD TRAVELER AND LOCOMOTIVE CRANE.

*Abstract of a paper read at the annual meeting of the Ohio Engineering Society.

†Chief Engineer, Interurban Railway & Terminal Co., Cincinnati, O.

different sizes, accurately weighed as above, shall pass into a "twin pug" or other approved form of mixer. In the mixture shall be added a sufficient quantity of Warren's Puritan brand bituminous waterproof cement, varied from No. 19 to No. 24, or material having the same chemical and physical characteristics to suit the stone used, in sufficient quantity to thoroughly coat all the particles of stone, and to fill all voids in the mixture.

The bituminous cement shall before mixing with the stone be heated to between 200° and 250° F.; the amount used in each batch shall be accurately weighed, and used in such proportion as has been previously determined by laboratory examination to give the best results and to fill the voids in the mineral aggregate. The mixing shall be continued until the combination is a uniform concrete. In this condition it shall be hauled to the street, and there spread on the prepared foundation to such a depth that, after thorough compression with a steam road-roller, it shall have a thickness of 2 ins. The proportioning of the varying sizes of stone and bituminous cement shall be such that the compressed mixture shall as closely as practicable have the solidity and density of solid stone.

SURFACE FINISH.—After the rolling of the wearing surface there shall be spread over it a thin coating of Warren's quick-drying bituminous flush coat composition, or material of the same chemical and physical characteristics, the purpose of this coating being to thoroughly fill any unevenness or honeycomb which may appear in the surface of the mixture. There shall then be rolled into the surface a thin layer of stone chips for the purpose of presenting a gritty surface which will not be slippery. The size of the stone chips to be subject to the special direction of the engineer. The stone chips will be of the same quality as stone specified for the wearing surface.

The roller used for compacting the earth foundation or subgrade for compressing the pavement base and wearing surface, also for rolling the stone chips, shall be operated by steam power, and give a weight pressure of not less than 650 lbs. per lin. inch of roller.

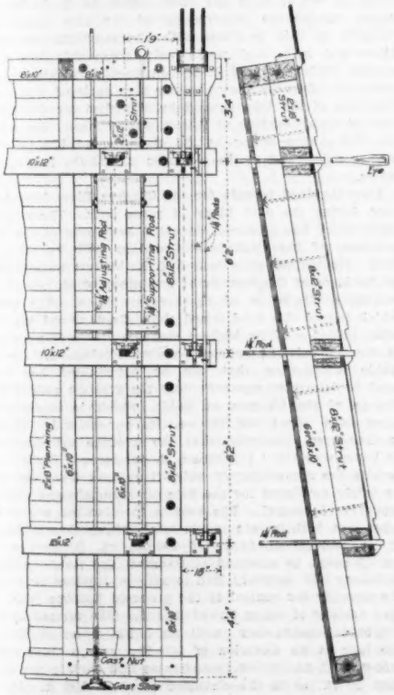
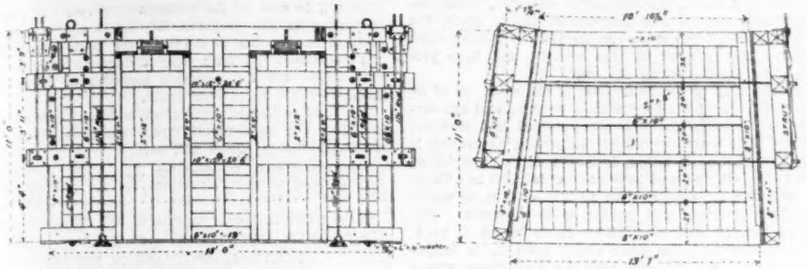


Fig. 6. Device for Locking End and Side of Mold.

Each layer of the work shall be kept free from dirt, so that it will unite with the succeeding layer.

PORTLAND CEMENT CONCRETE.—When on rolling the sub-foundation it is found impossible to make the street sufficiently solid to hold up the roller, the contractor shall be required to furnish Portland cement concrete foundation, to be laid under the following specifications: The concrete shall consist of mortar and crushed stone, gravel or slag which will vary in size from ¼-in. to 2 ins., mixed in such proportions as to provide a solid concrete. The mortar shall consist of 1 part of Portland cement to three parts of clean, sharp course sand, and shall be used with crushed stone used in predetermined proportions to give a firm, solid concrete. As soon as the concrete is well tamped, and before it becomes set, there shall be scattered over the surface of the concrete a sufficient quantity of clean broken stone of such size as will pass a 1¼-in. or 2-in. opening on a rotary screen. Sufficient of the stone to be used to about half cover the concrete. This stone shall then be tamped so as to become well bedded into the surface of the concrete, leaving a rough surface to the foundation of the pavement. The object of this binding course of crushed stone is to afford a rough surface to the concrete to enable the bitulithic wearing surface to more firmly adhere to the same.



Side Piece. End Piece

FIG. 5. GENERAL DESIGN OF SUBAQUEOUS CONCRETE MOLD.

If the fine crushed stone does not provide the best proportions of fine-grained particles, they must be supplied by the use of not to exceed 15% of hydraulic cement, pulverized stone, or very fine sand.

The bituminous cement shall be prepared by selecting bitumen which has been distilled from coal and passed in a gaseous state through water and purified by water, removing therefrom all matter soluble in water, and only that bituminous material shall be used which condenses from the gaseous state in water. The material selected shall be mixed in fixed proportions so as to give and produce a uniform condition as to the quantity of free carbon. The bituminous cement shall not be adulterated with any class of asphalt, coke-oven coal tar, water-gas coal tar, or any of the products of petroleum, and shall be especially refined and distilled at temperatures never rising above 450° F., using such forms of mechanical, steam, and air agitation as will accomplish uniformity of results, and remove as far as possible naphthalene and other matters most susceptible to atmospheric influences.

The bituminous cement shall be of such quality that when three ounces is placed in a glass dish 3 ins. diameter in the sun for two years it shall be decreased less in its penetration (taking the penetration of 1-16-in. below it surface) than the best quality of Trinidad-Lake asphalt paving cement for the same original penetration at 79° F. The bituminous cement shall be of such character that when 9 parts of the cement are mixed with 92 parts of sand which will pass a 20-mesh sieve and stand on a 30-mesh sieve, and placed in water, it shall show no discoloration at the end of three months when placed subject to the chemical influence of the sun, during parts of the day, and shall be firmer, as shown by testing on an ordinary cement tester at the end of six months, than a Trinidad asphalt cement submitted to the same condition will show at the end of two weeks.

The mineral ingredients shall be so arranged as to sizes that they will have inherent stability independent of the bitumen so as to stand a weight of at least three tons on a four-wheeled vehicle with 3-in. tires without the bitumen. The pure bitumen used in the wearing surface shall be of such softness that it will not be harder in penetration at 70° F. than a Trinidad asphalt paving cement composed of 100 parts refined Trinidad Lake asphalt and 30 parts petroleum residum at 18° Beaume.

The price bid per square yard to include repairs necessary to maintain the pavement in good condition, satisfactory to the Board of Public Service, for a period of five years from the date of acceptance by the city.

Under these specifications it is intended to get a wearing surface which is 2 ins. in depth over all, and it shall be the option of the bidder to use a bituminous binder course to level up the foundation or to level it up with a part of the wearing surface mixture. The binder course, if used, shall be fine particles of stone or gravel not to exceed 1 in. in diameter, thoroughly coated with Warren's Puritan brand bitumious waterproof cement, No 19 to No. 24, or material with the same chemical and physical characteristics.

The attention of bidders on the bitulithic pavement is called to the agreement on file with the council of the city of Cincinnati, under date of Oct. 3, 1904, and bidders are hereby notified that the sum of 25 cts. per sq. yd. will be retained from the contract price, and that the city will pay the same direct to Warren Brothers Co. for the patent rights and service therein granted.

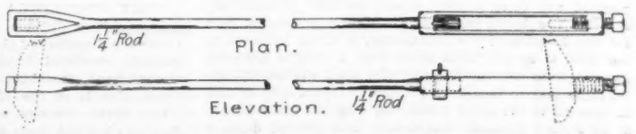


FIG. 7. ROD FOR FASTENING SIDES OF INTERMEDIATE MOLD.

REPORT OF THE COMMITTEE ON ENGINEERING OF THE ISTHMIAN CANAL COMMISSION.

The following report by Messrs. Wm. H. Burr and Wm. Barclay Parsons, Ms. Am. Soc. C. E., forming the Committee on Engineering of the Isthmian Canal Commission, has been submitted to Rear Admiral John G. Walker, U. S. N., who has furnished us advance sheets for publication. This report is dated Feb. 14 from Ancon, Isthmian Canal Zone, and outlines the work of the Engineering Committee between that date and Jan. 24, when the members arrived at Colon. As the report here appears in print for the first time, we give it practically in full:

The Committee on Engineering of the Isthmian Canal Commission sailed from New York on Jan. 17, 1905, and arrived at Colon on Jan. 24. Under resolution of the commission, Major General Geo. W. Davis, Governor, became a member of the committee during its stay on the Isthmus and acted continuously in that capacity until its departure.

The committee began its duties immediately upon its arrival and held its sessions and conferences daily at the office of the Governor, except when engaged in examinations of the actual or proposed work along the canal line. The chief engineer of the commission laid before the committee the entire data collected by the engineering field parties of his force, and such maps, plans and other records as had been prepared in his office up to the departure of the committee. He was also in attendance at the meetings and conferences of the committeee and on the field examinations which included visits to all the parties on the entire line, as well as to all points of interest and importance in connection with the work.

HARBOR IMPROVEMENTS AT COLON.

The interior harbor at the Cristobal entrance to the canal and the adjoining works received early consideration from the committee because extensive harbor accommodations are urgently needed at once to serve ships there in discharging plant, materials and supplies for the construction of the canal. These needs are already pressing and they will rapidly increase and become far more pressing in the near future.

CONDITIONS DURING STORM.—The committee examined in detail the site of this interior harbor, as well as the entire water front of Colon, on Jan. 27, while a severe norther was blowing, and its members were thus fortunate in viewing conditions bearing most impressively on the design and construction of the necessary works at the Atlantic end of the canal. The norther began blowing soon after noon of Jan. 26, with such force that three steamships in the harbor of Colon at that time were compelled to seek safety by putting to sea and remaining away for three days. The U. S. S. "Dixie" was preparing to leave at about that time and was obliged to hasten her departure to escape the danger of the storm. Not a vessel of any description remained in the harbor except two schooners in the slips adjacent to the Panama Railroad station, which were tied by a number of cables at a sufficient distance from their piers to prevent damage from excessive pitching and rolling. They could not get away and were compelled to ride out the gale in grave danger to themselves and to the neighboring piers.

At the time of the committee's visit, storm waves of great magnitude and force were rolling directly into the harbor, breaking over the entire water front of that part of Colon known as Aspinwall and blocking the marginal street with deluges of water and great quantities of coral rock and other debris. The same effects were produced on Cristobal Point, seriously injuring a number of houses and rendering them uninhabitable, as well as putting out of use the marginal street. The magnitude and violence of the wave action along the entire water front of Colon not only drove to sea every vessel that could get away, but it also endangered the piers or wharves, some of which have been heretofore seriously damaged in similar storms. Further than this, great inconvenience and some loss was caused, not only to the shipping interests affected, but also to the canal work in interrupting the discharge of cargo urgently needed, and in other ways injuring Isthmian transportation.

These storms occur on the average but once or twice a year, and during some years do not occur at all. For probably not less than 360 days in the year the harbor of Colon is free from any objection of this kind. If the construction of the canal were a purely commercial enterprise, the protection of an outer terminal harbor open to storms at rare intervals, as in this instance, would not be justified. This project, however, is a great public work by the United States Government, in which no feature contributing effectively to either safety or efficiency should be omitted.

It is, therefore, the unanimous and unqualified judgment of the committee that a harbor directly open to such heavy storm seas as to drive out shipping and endanger water front structures, even if the storms occur on the average but once or twice a year, is clearly unsuitable even for the outer harbor at the entrance of the Panama Canal where many ships must from time to time necessarily lie at anchor.

For these reasons, the committee unanimously recommend that plans and specifications be at once prepared for a breakwater extending across the mouth of Limon Bay

approximately on the line drawn from the light on Toro Point to the Colon Light. This breakwater will probably be designed in two parts, each about 4,000 ft. long, with an opening between them 700 to 800 ft. wide for the entrance of ships.

CONSTRUCTION OF BREAKWATER.—It is the judgment of the committee that the construction of that portion of the breakwater nearest to Colon should be commenced at the earliest practicable date. This would insure a substantial measure of protection in the near future for the piers and wharves of the Colon water front where ships may at all times transfer cargoes in safety. The remaining portion of the breakwater could then be constructed, if experience should show it to be necessary, or it can be omitted if there should prove to be sufficient harbor protection without it.

The rock required for the breakwater can be obtained of proper quality and in any desired quantity from the deep portions of the summit cut of the canal between Obispo and Culebra, from the quarry at Bohio and from Kenny's Bluff on the west shore of the Bay of Limon. The hard rock of the summit cut is well adapted to the requirements of the superstructure. The cost of quarrying is not, therefore, an element of cost of the breakwater.

Th interior harbor at the entrance of the canal immediately south of Cristobal Point, as proposed by the new Panama Canal Co., is urgently needed even at this time. Temporary timber pile wharves at Cristobal and adjacent to the entrance to the dry dock, half a mile further south, have already been completed and used, but they are of small capacity and there is insufficient depth of water in front of them. This harbor and the channel from the outer bay should be dredged at once and substantial timber quays or wharves should also be constructed immediately.

At its meeting on Feb. 1, this committee unanimously passed the following resolution, as shown by the minutes of its meetings accompanying this report:

(1) Resolved, That the committee approve and recommend to the commission 30 ft. as an immediate depth for the inner harbor at Cristobal and approach thereto, beginning at the 30 ft. contour in the outer harbor, and extending thence to Station 51, where it appears that indurated clay will be met at that depth. The width of approach channel should be about 500 ft., and that of the inner harbor about 1,000 ft., except as narrowed at the north end of Mangrove Beach Island to reduce coral rock excavation, and widened at turn to make a basin.

This harbor, so constructed as to bring conveniently along its quays the tracks of the Panama Railroad, will be of the greatest value during the entire progress of the canal work. In order to cover all possible contract work which it may be desirable to undertake along the approach channel and interior harbor heretofore contemplated as parts of a finished canal and entrance harbor, this committee, at the same meeting of Feb. 1, unanimously passed the following resolutions as expressing further recommendations to the commission:

(2) Resolved, That bids be invited for dredging from the outer harbor to Station 51 on the widths as in the preceding resolution, and from Station 51 to Station 100 for a width of about 1,000 ft., all at depths of 30, 35 and 40 ft.

(3) Resolved, That the material be classified as: (1) Coral and other rock; (2) indurated clay; (3) sand and mud; and that bids be asked for delivering material excavated by pumping at any point within 2,000 ft., as selected by the engineer, and with extra prices for each 1,000 ft. in addition. Hard material shall be carried to and dumped at sea within a maximum distance of three miles from Cristobal Point, as directed by the engineer.

(4) Resolved, That the chief engineer be directed to prepare the plans and specifications for the work, as indicated by resolutions Nos. 1, 2 and 3.

Although the interior harbor and approach channel as planned and recommended should be built immediately, it is the unanimous judgment of this committee that with the construction of the breakwater, a direct entrance to the canal at or near Boca Mindi with a straight approach channel from the outer harbor has such substantial advantages that it should be adopted, independently of and in addition to the canal connecting with the inner harbor as heretofore planned. Ships may then proceed directly through the outer harbor into the canal, or into the inner harbor for coal or other purposes, and thence into the canal. The proposed direct entrance and approach channel are shown on the plans submitted herewith by the chief engineer.

The estimated quantities of material required to be excavated, or to be used for the construction of the breakwater, are as follows: Common rock fill, 3,000,000 cu. yds.; hard rock, 400,000 cu. yds.

DIVERSION OF GATUNCILLO RIVER.

At the present time the waters of the Gatuncillo River flow through a diversion channel south of Gatun into the Chagres River at that point. The combined flow of the Chagres and Gatuncillo is taken almost entirely into the channel of the former to the point where it cuts the canal excavation, a short distance north of Gatun, where the joint discharge divides, the larger part following the Chagres to the sea and the remainder flowing through the canal excavation to Boca Mindi, where it escapes through the enlarged mouth of the Mindi River into Limon Bay. The natural result has been the formation of a large bar, filling almost the entire canal channel immediately north of Boca Mindi. This action has been intensified when floods have filled the Gatuncillo and Chagres Rivers.

The old Panama Canal Co. nearly completed what is known as the Gatuncillo diversion channel, located east of and mainly near to the canal line from the Gatuncillo River to Puerto Escondido in Manzanillo Bay. The continuation of this diversion southerly was partially excavated at numerous points from Gatun to Gamboa, easterly of the canal line, and it will probably have to be completed throughout that entire distance. Immediate attention, however, is directed to that portion already described and called the Gatuncillo diversion, which receives the waters of not only the Gatuncillo River, but also of the Mindi and other smaller streams flowing down from the high ground in that vicinity, and thus prevents them from entering the canal.

Whatever may be the final plans of the canal, or of its subsidiary work, this diversion must be completed and employed to discharge the waters it received into Manzanillo Bay. The bottom width of the present excavation is about 115 ft., and it originally had a depth of water of about 15 ft. Silt and mud have now settled in it to a depth of 1 to 3 or 4 ft., leaving from 10 to 13 or 14 ft. of water. Two short stretches still remain to be excavated, one, back of Monkey Hill, about 1,600 ft. in length of hard, indurated clay and the other about 2,000 ft. in length mostly of mud, silt and sand, near the Mindi River, where the railroad crosses its line; besides any enlargement of section that may be necessary.

Two small dams must also be constructed about 2,500 ft. apart, across the Chagres River near Mindi, to retain within the diversion channel the waters which must not enter the canal. A diversion of the Chagres on the westerly side of the canal, in the same vicinity, must be retained to take the flow of the Chagres directly to the ocean. Another dam must be built across the Boca Mindi, on the line of the railroad, to prevent the discharge of the Gatuncillo diversion through that opening which its waters now follow. These three dams and the Chagres diversion are necessary to complete the separation of the waters intended to flow through the Gatuncillo diversion and the Chagres River.

All the works thus far discussed are quite independent of the type or dimensions of the canal south of Gatun and their construction is imperative; therefore, this committee unanimously recommends their immediate completion.

SUMMIT LEVEL OF CANAL.

Before other subsidiary questions can be decided or even considered, a determination must be reached as to the elevation of the summit level. The plan of the French Company under which they were working, placed this level at 97.5 ft. above mean tide, to be supplied with water from a storage lake at Alhajuela which was also to regulate the Chagres. The former Isthmian Canal Commission considered a summit level at 85 ft., to be maintained by a large dam at Bohio, making a lake with an area of 38.5 square miles, and thus regulating Chagres floods.

When the present commission was created it was realized that before a final determination could be made with propriety, additional data should be obtained other than that possessed by the French Company or secured by the former commission, and especially that positive information should be had as to the probable cost of excavation, for on such cost, both as to time and money, will the type of the canal in large part depend.

Survey parties were at once established and contracts let for the installation at Culebra of a modern excavating plant.

WORK AT CULEBRA CUT.—The work of excavation in the summit or Culebra cut has been actively prosecuted under the direction of the chief engineer so that the total quantity excavated during the month of January of the current year was about 71,000 cu. yds. The first three steam shovels of the 17 recently contracted for in the United States are now set up and at work, although the third one had not made a beginning of its work on Feb. 1. A shovel has exceeded a daily output of rock excavation of 1,000 cu. yds. The operations of the shovels have been entirely satisfactory and they have already proved themselves to be machines of high efficiency. Indeed, the results so far attained indicate that there is no other type of machine better adapted to the class of work to be done in the summit cut or which can reach a greater efficiency. The French excavators have also been put in a much more efficient condition so that in clay excavation a single machine has also reached a daily output of nearly 1,400 cu. yds., but they are not well adapted to rock.

COST OF EXCAVATION.—As a result of the experience thus far gained in the actual rock and clay excavation at Culebra, the average monthly cost per cubic yard has fallen below 50 cts. The chief engineer, therefore, is confident that the average cost of all the excavation in the summit cut will not exceed 50 cts. per cu. yd., and this committee concurs in that opinion. The former Isthmian Canal Commission assumed in its estimates that the average cost of excavation in the great summit cut would be 80 cts. per cu. yd. The demonstrated cost of this commission's actual work at Culebra, if applied to the quantities employed by the former commission, would reduce the total estimated cost of the canal about $15,000,000. This large saving in cost makes a fundamental reconsideration of canal plans by this commission essential. It is obvious that this actual reduced cost of excavation justified a reduction in the elevation of the summit level of the canal by a correspondingly greater volume of excavation. After a careful consideration of all the elements of this portion of the canal problem, this committee, as an expression of its judgment, passed unanimously the following resolution at its meeting on Feb. 1:

(7) Resolved, That the elevation of the summit level of the canal should not exceed 60 ft.

As will be seen by the accompanying report of the chief engineer,* he has prepared full statements of estimated costs of construction of the canal for three different summit elevations: (1) With summit elevation at 60 ft. above mean tide. (2) With summit elevation at 30 ft. above mean tide. (3) A sea level canal.

The total estimated costs of these three types of canal, including the breakwater, direct approach channel and interior harbor at Colon will be:

Summit level at 60 ft. elevation	$178,013,[illegible]
Summit level at 30 ft. elevation	194,215,[illegible]
Sea level	230,475,[illegible]

These totals include a margin of 20% for contingencies, administration, sanitation and engineering.

CONTROL OF CHAGRES RIVER.

The effective control of the Chagres River, especially during its floods, which are frequently sudden and of great volume, has also been considered in all its relations to the plans of the canal which may ultimately be adopted. Inasmuch as the elevation of the water in the Chagres River at Gamboa is about 55 ft. above mean tide, or but 5 ft. below a summit level placed at 60 ft. above mean tide, it is the judgment of this committee that the control of the Chagres River, with a summit level at an elevation of 60 ft. or less, should be effected at or in the immediate vicinity of Gamboa, which the examinations made by the field party operating at that location and in the valley of the Chagres above Gamboa, show to be entirely feasible.

For these reasons, the committee unanimously passed the following resolution, expressing its recommendation to the commission at the meeting of Feb. 1:

(8) Resolved, That in the event of the commission approving resolution No. 7, that the Chagres River be retained by a dam located at Gamboa, and built to a crest height of about 200 ft.

The complete data secured by the surveys and examinations of that field party are given in the report of the chief engineer. They show that the high hills on both sides of the river at Gamboa, in connection with the maximum depth of bed rock in the river, about 56 ft. below low water, render the construction of the dam across the Chagres at this location, with the attendant works of pipes and gates and waste weir, reasonably free from serious difficulties and bring construction within reasonable cost. Surveys show that the area enclosed within the flow line of the lake formed by this dam for the elevation of water surface at 200 ft. above mean tide, would be 43.3 square miles; at the elevation of 170 ft., 30.8 square miles, and at the elevation of 132 ft., 14.9 square miles.

Accurate flood records for the Chagres River have been kept during the past 13 or 14 years only. The greatest flood which has occurred since the beginning of the construction of the Panama Railroad in 1851 was that of 1879. No authoritative record of the highest water, either at Bohio or at Gamboa, or at any other point, nor of the maximum discharge of that storm exists. The storm which caused this flood lasted about six days and approximate evidence of its highest stage at Bohio is preserved in the memories of some persons now living. All the reliable information that can be ascertained has been used to determine approximately the greatest rate of discharge of the Chagres at Bohio, which is supposed to have been about 136,000 cu. ft. per second. It has further been concluded that the average discharge for 48 hours was about 112,000 cu. ft. per second. While these results are approximately only, it appears that they may be safely employed for the determination of some general features of control. The results for Gamboa are somewhat less, both in rate and in total volume than at Bohio. If an average discharge of 100,000 cu. ft. per second for 72 hours be assumed at Gamboa, the resulting computations will certainly lead to safe conclusions regarding the capacity for control of the proposed Gamboa lake. If that amount of water flowed into the lake formed by the proposed Gamboa dam, with an initial water surface of the lake at an elevation of 160 ft., such a three days' inflow, with no outflow, would raise that surface not more than 30 ft., or to the elevation of about 190 ft. If, on the other hand, a uniform outflow of 20,000 cu. ft. per second were maintained during the same length of time, the resulting rise of lake surface would be but a little over 20 ft., thus raising the elevation of that surface to slightly above 180 ft. The Gamboa lake, therefore, may be used in this manner as an effective control of the Chagres River, even during the highest flood which there is any reason to anticipate.

The greatest volume of continuous inflow into the lake which could take place under the authentic records of the

*Not printed here.

past 14 years, is about 365,000 acre-feet per month for six consecutive months in 1892, and of 700,000 acre-feet for one month in 1894. A continuous outflow of not more than 10,000 cu. ft. per second during these two periods of inflow, would enable the lake to take care of both these periods of great discharge, without raising the surface of water more than a few feet and for a short period only. While further detailed studies beyond those which were available to the committee on the Isthmus, are required to determine the exact elements of this problem of the control of the Chagres during varying periods of high rates of inflow, the examination made by this committee shows conclusively that the lake proposed has sufficient capacity to afford abundant regulation of the Charges floods.

The necessary rates of the outflow from the lake during flood periods may be obtained by means of large pipes and gates built into the dam itself, together with a waste weir at the same point, or by means of a tunnel about 3.4 miles long through the dividing ridge between the Chagres and Gatuncillo watersheds, or by both. The elevation of the invert of this tunnel at the Chagres end may be placed at 153 ft. above mean tide. If such a tunnel were built at the elevation named, with a diameter of 30 ft., it could be depended upon to discharge 15,000 cu. ft. per second, with the elevation of water surface between 180 and 185 ft., the mean velocity of water through the tunnel being about 20 feet per second. At least the same rate of discharge, and a greater one, if required, may be obtained through properly controlled pipes at the dam, discharging either into the canal or into a diversion channel on the easterly side of the Chagres River, constructed the entire distance to the Gatuncillo diversion or into both.

Surveys for the location and estimate of cost of the tunnel for discharging into the upper waters of the Gatuncillo, have already been completed, as well as for a similar tunnel to discharge into the Pacific. Complete surveys are about to be undertaken to ascertain the exact amount of work which has been done on the Chagres diversions between Gamboa and Gatun, so as to make an accurate estimate of the cost of their completion. As soon as these latter surveys are completed, the exact estimates of cost, both for the tunnel and for the diversion discharge, can be made, and all the details of those features of the regulations works can be determined.

Work on the foundation for the dam at Gamboa can be begun at once. This portion of the construction of the dam will probably require from a year to a year and a half of time, and it is the unanimous judgment of the committee that it should be undertaken immediately, and that the construction of the entire dam should be completed as soon as possible.

The building of the dam at Gamboa will not only furnish complete and effective means of control for the Chagres floods, but it has the further advantage of being entirely accessible by the Panama Railroad for the transportation of men and materials. The plan of the dam will probably require a masonry core, with a great mass of earth and rock fill on either side of it, from the waste excavation of the summit cut. The plan, therefore, has marked merits of both efficiency of control and economy of construction.

The conditions attending the construction of this dam are in no way unprecedented. The depth of bed rock below water surface is only about one-third that at Bohio and no greater than has already been reached by the use of heavy timber sheet piling for founding masonry structures in the United States.

The proposed height of this dam from its foundation to its top is far less than found in a number of masonry dams already built, and the making of the earth embankments on the two sides of the masonry core is simply wasting the material from the summit cut. The construction of the Gamboa dam, therefore, involves no formidable obstacles not heretofore successfully encountered in engineering practice.

The practicability of certainly and satisfactorily controlling the floods of the Chagres by so simple and economical a method as the Gamboa lake and its outflow channels, and the reduced cost of excavation as actually demonstrated by the work of the commission in the Culebra cut, makes the construction of a sea-level canal at a reasonable cost, far more available than has heretofore appeared possible. These recent developments in the conditions attending the construction of the canal are so important as to be almost controlling in character. The remaining element is that of the time required to make the great summit excavation. It is to be carefully observed that the results thus far obtained in the Culebra cut have been reached under disadvantageous conditions of both organization of plant and force. The railroad tracks serving the excavators are yet fragmentary and tentatively placed to serve the purpose of investigation. In both respects the disposition of plant is far more unfavorable, both to economy and celerity of operations, than will be the case when a complete track system has been arranged and laid down to serve a large number of steam shovels operated by an experienced force. In the face of these disadvantageous conditions, the cost of excavation has been reduced far lower than was anticipated and it has been demonstrated that each steam shovel may be counted upon to yield an average record of at least 1,000 cu. yds. per working day. The chief engineer estimates that with 100 steam shovels installed, with a complete system of tracks serving them, a yearly record of 30,000,000 cu. yds. of excavation may be reached without requiring a greater output per shovel, or greater speed in working, than has already been attained. This rate of working could probably be reached within two years from the present time.

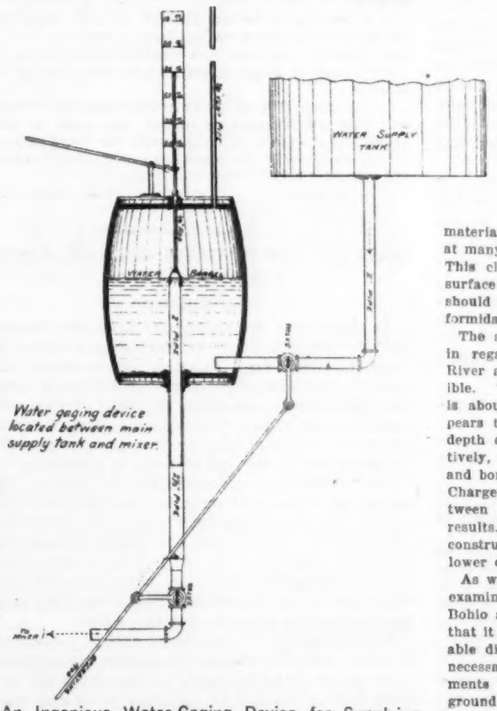
With the rate of progress which now appears reasonable to anticipate, this committee believes that a sea-level canal, with a tidal lock 1,000 ft. long and 100 ft. usable width, at Miraflores, can be completed within 10 to 12 years from this time, the bottom width of the canal being 150 ft. and the minimum depth of water 35 ft.

These considerations have induced this committee to express to the commission its unanimous judgment that with the contemplated system of working, and with the rate of development which appears to be justified by the work now being performed at Culebra, a sea-level canal, free from the restriction of locks, should be adopted. This committee believes that such a canal with terminal harbors, can be constructed for a sum not exceeding $230,500,000.

SEA LEVEL CANAL RECOMMENDED.

The advantages of a sea-level canal across the Isthmus are most obvious. It would be a waterway with no restriction to navigation and which could easily be enlarged by widening or deepening at any time in the future, to accommodate an increased traffic, without any inconvenience to the shipping using it. Whereas, a lock canal is in reality a permanent restriction to the volume of traffic and size of ships that use it. Although it is possible to design and construct locks adapted to the future transformation of a sea-level canal, that transformation cannot be made without serious inconvenience to navigation and at a cost so great as to be excessive. The additional cost of a sea level canal over that of a canal with locks, with a summit level of 60 ft. above mean tide, is $52,462,000, or $79,742,000 more than the estimated cost of the lock canal with a summit level 85 ft. above mean tide, proposed by the former Isthmian Canal Commission, after allowing $6,500,000 for the Colon breakwater and direct entrance not previously estimated.

This committee considers this additional expenditure fully justified by the advantages secured.



An Ingenious Water-Gaging Device for Supplying Water to a Concrete Mixer.

DIMENSIONS OF CANAL.

This committee has considered most carefully suitable dimensions for the cross sections of the Canal to be built. It has had in view the dimensions of the ship canals now built and in use, such as the Suez, the Manchester, the North Sea, and other similar waterways. The fact has also been carefully borne in mind that the city of New York is deepening its entrance channel to 40 ft. On the other hand, it is recognized that the depth of the Suez Canal is less than 30 ft., that the depth of the Manchester Canal is 26 ft., the North Sea Canal 29½ ft., and the Corinth Canal 26 ft. It is also recognized that at the present time no loaded ship either enters or leaves the harbor of New York drawing more than about 33 ft. It is believed therefore, that for many years the commerce seeking the Panama Canal will be amply accommodated by a depth of water not exceeding 35 ft.

In view of these considerations, this committee expresses its recommendation to the commission in the following two resolutions, unanimously passed in its meeting of February 3d.:

(9) Resolved, That 150 ft. be recommended as the minimum bottom width.

(10) Resolved, That 35 ft. be recommended as a minimum depth, but that estimates be prepared for a depth of 40 ft. as well.

If a canal with locks should ultimately be determined upon, this committee is of the opinion, in view of the restrictions which such structures impress upon a growing commerce, and in view, also, of the difficult and costly process of transformation to a sea-level canal under any practicable conditions, that the locks should be made of 1,000 ft. usable length and 100 ft. usable width, but fitted with intermediate gates so as to accommodate small ships with less consumption of water and less time required to pass the locks.

The borings along the sites proposed for the dam across the Chagres near Bohio have shown that bed rock is deeper than has been supposed at all the sites contemplated. The greatest depth to rock, both at the French site and on that tentatively proposed by the former Isthmian Canal Commission, is about 158 ft. below sea level, and but little less at a third site a short distance up stream from the former, as shown by the borings thus far made. These results indicate greatly increased difficulties in the construction of any dam in the vicinity of Bohio. Further borings are now being made at a site near Buenavista, little more than half a mile above the French site, where the bed rock seems to be at sensibly less depth. The investigations now in progress will soon be completed. Their completion is necessary to determine the most advantageous dam site in the vicinity of Bohio or Buenavista, if such a dam should be required. These borings, like others previously made in this location, have disclosed coarse gravelly material freely water bearing down to bed rock at many points, as well as occasional fragments of timber. This clearly indicates the necessity of cutting off subsurface flow along the deepest bed rock, in case a dam should be built at this location. These conditions are formidable because they are found at such great depths.

The surveys and examinations which have been made in regard to a possible dam site across the Chagres River at Gatun, show that such a structure is not feasible. The width of the floor of the valley at that point is about 5,000 ft., and two borings made at what appears to be the most favorable section penetrated to a depth of 172.7 ft. and 139.2 ft. below sea level respectively, without finding bed rock. Other examinations and borings have also been made at other sections of the Charges valley where a dam site seemed possible, between Gatun and Bohio, but with equally unfavorable results. It is clear, therefore, that it is not feasible to construct a dam across the Chagres River at any point lower down in its course than at Bohio.

As will be seen by the report of the chief engineer, the examinations made along the alternative line between Bohio and Gatun, known as the Tiger Hill cut-off, show that it will be costly to construct and that for a considerable distance between Tiger Hill and Bohio it would be necessary to retain the water in the canal by embankments not less than 20 ft. high, in some cases on soft ground. This committee is, therefore, unanimously of the opinion that it is advisable both on the score of economy and of safety of construction, to retain the present canal line between Gatun and Bohio.

At the meeting of this committee, held on Feb. 14, the following resolution was unanimously adopted:

(13) Resolved, That this commission approve and recommend for adoption by the commission a plan for a sea-level canal, with a bottom width of 150 ft., and a minimum depth of water of 35 ft., and with twin tidal locks at Miraflores, whose usable dimensions shall be 1,000 ft. long and 100 ft. wide, at a total estimated cost of $230,500,000. Such estimate includes an allowance for administration, engineering, sanitation and contingencies, amounting to $38,450,000, but without allowance for interest during construction, expense of Zone Government and collateral costs, and water supply, sewers, or paving of Panama or Colon, which last items are to be repaid by the inhabitants of those cities.

A DEVICE FOR MEASURING WATER ADMITTED TO A CONCRETE MIXER.

The accompanying illustration shows an ingenious and simple water-gaging device for supplying the desired percentage of water to a batch of concrete in a mixer. An ordinary oil barrel is connected with a water-supply tank by a 2-in. pipe provided with a valve. Through the bottom of the barrel passes a 2½-in. pipe, also provided with a valve, which is connected with the other valve by a rod, as shown. Telescoping into the 2½-in. pipe is a 2-in. plunger pipe, which can be

raised or lowered by means of a lever. A stuffing box in the bottom of the barrel prevents leakage around the 2-in. plunger pipe. A ¾-in. "vent pipe" extends vertically from the head of the barrel up to the level of the water in the supply tank. Starting with the barrel full of water, the operator raises or lowers the 2-in. plunger pipe till the rod attached to it marks the desired percentage of water; then he pulls a rope attached to the lever that operates the two valves, thus opening the lower valve and closing the upper one simultaneously. The water in the barrel then discharges into the mixer until it reaches the level of the open top of the 2-in. plunger pipe, when, of course, no further discharge takes place. The operator then releases the rope operating the valves, and a counterweight (not shown in the drawing) pulls them back to their original position, closing the lower valve and opening the upper valve, which permits the barrel to be filled again from the supply tank.

This ingenious device is described by Mr. Clarence Coleman, Assistant Engineer, in the last annual report of the Chief of Engineers, U. S. A., Vol. 8, Part IV., p. 3783.

A REPORT RELATING TO THE ADVISABILITY OF ACCEPTING UNIT-PRICE BIDS.

The Superintendent of Public Works of the State of New York, who is in charge of the letting of the contracts for the Barge Canal, called for bids both by lump sum and by unit prices. Most of the contractors submitted unit-price bids only, but a few lump-sum bids were received, and the question arose as to whether a lump-sum bid was to be preferred to a unit-price bid or not.

To settle the matter, the Superintendent of Public Works submitted five questions to the Advisory Board of Consulting Engineers. The answers to these questions are of such general interest to engineers and contractors that we print the report of the Board in full. The Board, it should be stated, consists of five well-known engineers, namely: Edward A. Bond, Chairman; William A. Brackenridge, Elmer L. Corthell, Alfred Brooks Fry and Thomas W. Symons. Their report follows:

Hon. N. V. V. Franchot, Superintendent of Public Works, Albany, N. Y.:

Dear Sir—In reply to your letter of Jan. 31, 1905, making request of this Board for advice on certain points, the Board has the honor to state as follows:

(1) As to your understanding, under the terms of the proposals for any given contract, as to the comparative advantages to the State as between the two forms of proposal.

Answer.—It is the opinion of this Board that it is to the advantage of the State to let contracts under unit-price proposals rather than under lump-sum proposals. It is pertinent to add that this Board has never been in favor of or recommended asking for lump-sum proposals.

(2) As to your understanding, from a technical standpoint, of what is embraced in actuality in a lump-sum proposal.

Answer.—It is the understanding of the Board that a lump-sum proposal includes the work provided for and limited by the plans and specifications governing said work.

(3) To what extent final payments in equity to the contractor might be changed or affected by a change of plans for doing or progressing the work under the given contract.

Answer.—With a contract based on unit prices, the equitable settlement with a contractor is provided for in advance of the execution of the work by the nature of the specifications, and would be simply to apply the unit prices to the amount of work actually done by the contractor. In case of a lump-sum contract, it is difficult to see how an equitable settlement with a contractor could be arrived at under conditions necessitating work beyond that required by the plans and specifications. With a lump-sum contract the contractor would get all the advantages arising from a lessening of the quantities below those required by the plans and specifications, while for all work not covered by the plans and specifications he would be in position to demand any prices that he saw fit to charge. In order that a lump-sum contract should be equitable to both parties, unit prices for additional or diminished work should be specified, and this would make it practically a unit-price contract.

(4) In the event of a change in plans affecting the manner or method of doing the work, or changes increasing or diminishing the amount of work to be done, or calling for work not contemplated in the plans as they exist at the time of execution of contract, what basis might and does exist, or what basis might be devised for arriving at a price to be allowed to the contractor for the additional or extra work, or to the State by the contractor, in the event of a reduction of work to be done?

Answer.—The answer to this is included in the answer to question 3.

(5) As to what information, reason or argument, technical or otherwise, your Board, in the capacity of advisor, may suggest, cite or furnish, which will assist me in the performance of the "duty and discretion conferred upon" me by the statute, me, and me alone, paraphrasing the Attorney-General's opinion, in determining as between a proposal under the item-price plan and a proposal under the lump-sum plan, the total of the proposals differing in amount on the face of the proposals, which of the two offers "to do and perform the same at the lowest price to the State."

Answer.—Responding to these questions, the Board begs to state that for the kind of work included in the improvement of the State canals, it is the practically universal custom to let contracts under the unit system. In response to your request to furnish you with information on the subject, the Board submits to you herewith a copy of an editorial in the Engineering News on the question of lump-sum proposals. The Board also begs to state that the United States Engineers Corps has for many years been engaged in canal work and other public works of similar character in all parts of the country, and has had more experience in such work in the United States than any other body of men. Inquiry made from the officers of this Corps shows that lump-sum contracts are never seriously considered for this character of work, and that the universal practice is to let contracts on the unit-price system.

It is the opinion of this Board that lump-sum contracts should not be made, and that all engineers of experience in public work of this character would coincide in this opinion.

It is believed to be impracticable to make lump-sum contracts which would be just both to the State and to the contractor, and that such contracts would almost inevitably lead to litigation and probably large loss to the State.

In the class of work under consideration, as between two bids exactly equal in amount, one based on unit prices and the other as a lump sum, the Board believes that it would be to the advantage of the State to accept the unit-price bid. Very truly yours,

(Signed) Edward A. Bond, Chairman.

Albany, N. Y., Feb. 2, 1905.

GRASS AND WEED DESTROYER, GUAYAQUIL & QUITO RAILWAY, ECUADOR.

By John A. Harman.*

In describing the construction of the Guayaquil & Quito Railway in Engineering News, of Aug. 11, 1904, brief mention was made of the special weed killing train employed to keep down the vegetable growth along the right of way. As considerable interest has been manifested in the character of this apparatus and its operation the following more detailed account is presented.

The destruction of vegetation is effected by means of a chemical mixture, the ingredients of which are water, arsenical acid and nitrate, in the following proportions: one pound of arsenical acid to five gallons of water and one pound of nitrate to six gallons of water. The arsenical acid being practically insoluble in cold water, can only be dissolved by superheating the water.

The mixing plant is composed of four tanks and a boiler, with the proper steam pipe connections. Two of the tanks are used for dissolving the nitrate and arsenical acid, and may be of any convenient size, but in the capacity proportion of five to six, so that the mixture will be of the proper proportion when it is run into the receiving tank. The receiving tank may also be of any convenient size, but for economy, should scarcely be of less capacity than 25,000 or 30,000 gallons. It is arranged as an ordinary railway water tank for supplying locomotives. The fourth tank, which is the distributing tank, is mounted on a car. Where the haul is for a short distance, one tank containing from 5,000 to 10,000 gallons, is sufficient, but, where the haul is greater, it would be more economical to have two or more tanks, in order not to have to return too often to the mixing plant. The best arrangement of the plant is such as will give a gravity flow from the two dissolving tanks into the receiving or mixing tank, and from that into the distributing tank. It is not absolutely necessary that the water in which the nitrate is to be dissolved should be heated, but quicker and better results are obtained by slightly heating the water, and it is therefore better to have a coil of steam pipe in this tank. As before stated, it is absolutely necessary to have the water in which the arsenical acid is to be dissolved superheated. This is effected by placing one or two coils of steam pipe in the tank, and by covering the tank during the process of dissolving. The ordinary upright boiler is the most satisfactory and economical method of supplying the necessary heat to the dissolving tanks.

There is some danger to the operatives of nitrate or arsenical poisoning, unless great care is exercised. This poisoning is in the form of irregular ulcers, which have a tendency to spread and run into each other, but if the operatives are careful to wear clean wet sponges over the nostrils during the heating process, and not to touch any part of the body where the mucous membrane is exposed while the poison is on the hands, and if they bathe thoroughly immediately after completing their tasks, this poisoning can readily be avoided. In this connection, it is desirable and convenient to have a good shower bath established in connection with the plant and require the men to strip and thoroughly wash themselves immediately after their tasks are completed.

Having run the liquid mixture into the distributing tank, it is then run out to the site upon which the vegetation is to be destroyed, and is sprinkled over the track and to the sides, after the fashion of an ordinary street sprinkling wagon, except that, in order to get a uniform flow and the best results, gravity cannot be depended upon, but the liquid must be forced uniformly through the sprinklers by means of compressed air or steam, carried to the tank from the engine. By increasing or decreasing the air or steam pressure, the stream can be thrown from 5 to 15 ft. on each side of the track, and the space cleared will accordingly vary from the width of the track plus 10 to 30 ft.

The cost of the plant and the cost of applying the mixture on the right of way will always vary in different countries and different localities, but, so far as tropical vegetation is concerned, it is probably the most effective and cheapest process or method yet devised for the destruction of vegetation.

Best results are obtained by applying the mixture to the track at a speed of about four miles per hour, and when the weather is dry and hot, so that the sun withers the vegetation and assists in killing the grass and weeds, but this is not absolutely necessary. The average number of gallons of the mixture used per mile here, where the vegetation is luxuriantly tropical, is 1,666. At first the applications should be made at intervals of about three months, but, as the ballast and soil near the track become more and more permeated with the poison, this interval of time can be increased.

This process was perfected and patented by a gentleman now deceased, but it has been known and more or less experimented with in Central and South America for some years past.

*Chief Engineer and General Manager Guayaquil & Quito Ry., Box 37, Guayaquil, Ecuador.

THE LARGEST PASSENGER SHIP IN THE WORLD, the "Caronia" of the Cunard line, has had her official trial trips. She is 675 ft. long, 72 ft. beam, and 13,500 tons launching weight. Her displacement when fully loaded, and drawing 33 ft. is 31,000 tons. The guaranteed speed is 18 knots, but when running light she has made 19¼ knots.

TRANSATLANTIC TURBINE STEAMERS will soon be an important element in transatlantic fast service. The Allan Line steamer "Victoria" is nearly ready for the first trip; this will be the first turbine steamer for regular transatlantic service. The Cunard steamer "Carmania," a 21-knot turbine vessel 678 ft. long and 21,000 tons register, was launched on Feb. 21, 1905, and will probably be the second to go into service.

AN UNUSUAL RAILWAY ACCIDENT occurred on the Canadian Pacific Ry. at Shelburne, Ont., on Feb. 17. Three engines which had just freed themselves from a snow blockade collided with three engines coming to relieve them. None of the men were killed, but the six engines were badly wrecked.

A GREAT FREIGHT PIER FIRE at New Orleans, La., on Feb. 26 and 27, 1905, destroyed some five millions dollars of property. The principal loser is the Illinois Central Ry., whose shipping terminal piers and freight sheds were completely burned away. These terminals extended nearly a mile along the river front, from Louisiana Ave. to Napoleon Ave., and besides numerous pier sheds included two large grain elevators.

A COAL MINE EXPLOSION occurred Feb. 20, in the Virginia Mine, 18 miles southwest of Birmingham, Ala., resulting in the death of more than 100 miners. The mine is said not to have been a gassy mine, and it is believed that a dust explosion occurred. The mine is owned by the Alabama Steel & Iron Co., but is leased to Reid & Co.

Another explosion in Shaft No. 1 of the United States Coal & Coke Co., at Wilcoe, West Va., Feb. 26, killed 23 miners. The cause of the explosion is not known. Had the explosion occurred on a week day, instead of Sunday, the loss of life would have been much greater.

A FLOOR COLLAPSE in Brooklyn, N. Y., on the evening of Feb. 27, 1905, caused the death of a dozen persons. A funeral celebration was being held in a small church, and the auditorium, which was on the second floor above the Sunday-school rooms, was crowded with mourners. About the time the pall bearers started up stairs with the body, the floor of the auditorium sagged at one end and then sank down completely to the floor below. The building was of timber frame construction and was very old, having been built something over 50 years ago, according to local report. It was greatly overcrowded on this occasion, and the accident is chargeable to overcrowding rather than to such a degree of weakness as would justify condemnation. According to published statements of the building department, no evidence of decay in the floorbeams is reported.

A SINGLE-PHASE ELECTRIC INTERURBAN TROLley line running out from Indianapolis, Ind., to Rushville, Ind., a distance of some 40 miles, has been in operation for the past month. The line uses series alternating-current motors of the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa. The trolley wire voltage is 3,300 volts, alternating (25 cycles), in the open country; 550 volts alternating in the city of Rushville; and 550 volts direct current in the city of Indianapolis. The line is mainly single track at present, and is on private right of way, except within cities, where the streets are used directly. A maximum speed of 45 miles per hour, for a schedule speed of 30 miles per hour, is provided for by 4 75-HP. motors on each (double-truck) car. Multiple-unit rheostatic control is used, so that the cars may be run in trains when desired. The overhead work is of the catenary form. A 7-16-in. steel suspension cable passes over porcelain insulators set on the bracket arms of the poles, and from this wire a 3-0 grooved copper trolley wire is hung by short suspenders 10 ft. apart. The trolley wire is 18 ft. above top of rail. A bow trolley is provided for the high-voltage portions and a wheel trolley for the low-voltage portions of the line, each car thus having two trolleys. The rails are standard T-rails weighing 70 lbs. per yd., bonded and cross-bonded. Current is supplied from a single generating station at Rushville, transmitted at 33,000 volts, 25 cycles, single-phase. The transmission line to the substations is of two 4-0 bare copper wires. Two telephone circuits are carried on the transmission line poles, one circuit being exclusively for dispatching. Telephone boxes are placed on the poles, about half a mile apart, from where the conductor can call up the dispatcher for orders. It is planned to extend the line ultimately to Cincinnati, O.

ENGINEERING MATERIAL PRICES.

(These prices will appear in the first or second issue of each month.)

TRACK FASTENINGS—
Chicago—at mill—Angle bars, 1.40 to 1.50 cts.; spikes, 1.70 to 1.75 cts.; track bolts, 2.40 to 2.50 cts.

RAILS, STEEL—
New York—at mill—New standard sections, $28; light rails, $23 to $24.50; old iron, f. o. b. New York, $22 to $22.50; old steel, rerolling lengths, $17 to $18; old steel, short pieces, $16 to $16.50; relayers, $20 to $21.
Chicago—at mills—New, $28, standard sections; light rails, $24 to $28; old iron, $19.50 to $20; old steel, 4 ft. and over, $15 to $15.25; old steel, less than 4 ft., $14.50 to $15; heavy relayers, $22.50 to $23; heavy relayers for side tracks, $20 to $20.50.
Pittsburg—at mill—Standard sections, $28.

STRUCTURAL MATERIALS—
New York—at tidewater—Beams, channels, angles and zees, 1.74½ to 1.84½ cts.; tees, 1.79½ to 1.89½ cts.; bulbs, angles and deck beams, 1.84½ to 1.94½ cts.
Chicago—Beams and channels, 3 to 15-in., inclusive, and angles 3 to 6-in., ¼-in. and heavier, 1.76½ cts.; tees, 3-in. and over, 1.81½ cts. Store prices, angles, beams and channels, 1.92 cts.
Pittsburg—Beams and channels, up to 15-in., 1.60 cts.; over 15-in., 1.70 cts.; angles, 3 × 2 × ¼-in. thick up to 6 × 6-in., 1.60 cts.; angles, 8 × 8 and 7 × 3½ ins., 1.70 cts.; zees, 3-in. and larger, 1.65 cts.; tees, 3-in. and larger, 1.65 cts.

PLATES AND SHEETS—
New York—at tidewater—Sheared plates, carload lots, tank, 1.74½ to 1.84½ cts.; flange, 1.84½ to 1.94½ cts.; marine, 1.94½ to 2.04½ cts.; fire box, 1.94½ to 2.50 cts.
Pittsburg—Tank, ¼-in. thick 6¼ to 14-in. wide, 1.50 cts. at mill, Pittsburg; flange and boiler steel, 1.60 cts.; marine and ordinary fire box, 1.70 cts., at mill, Pittsburg; locomotive fire box, 2 cts.

MERCHANT STEEL—
Chicago—Machinery, smooth finished, 1.81¼ cts.; tire, smooth finished, 1.76½ cts.; railway spring, 1.76½ cts.; crucible tool, 6½ to 8 cts.; special tool, 13 cts. and up.
Pittsburg—Open hearth spring steel, 2 to 2.10 cts.; tire steel, 1.60 to 1.65 cts.; smooth finished machinery steel, 1.60 cts.; toe calk steel, 1.90 to 2 cts.

IRON—
Pig Iron:
New York—No. 1 X Foundry, $17.75 to $18.25; No. 2 X Foundry, $17.25 to $17.75; No. 2 Plain, $16.50 to $17; Gray Forge, Northern, $16 to $16.50; Southern No. 1 Foundry, $17.25 to $17.75.
Chicago—f. o. b., Chicago.—Lake Superior charcoal, $18.50 to $19; Northern Coke Foundry, No. 1, $18; Northern Coke Foundry, No. 2, $17.50; Northern Coke Foundry, No. 3, $17; Northern Scotch, No. 1, $18 to $18.50; Ohio Strong Softeners, No. 1, $19.30 to $19.80; Ohio Strong Softeners, No. 2, $18.80 to $19.30; Southern Silvery, 4 to 6% Silicon, $18.65 to $19.65; Southern Coke, No. 1, $17.65 to $17.90; Southern Coke, No. 2, $17.15 to $17.40; Southern Coke, No. 3, $16.65 to $16.90; Southern Coke No. 4, $16.40 to $16.65; Southern Coke, No. 1, Soft, $17.65 to $17.90; Southern Coke, No. 2, Soft, $17.15 to $17.40; Southern Gray Forge, $16.50 to $16.75; Southern Mottled and White, $15.90 to $16.15; Malleable Bessemer, $17.50; Standard Bessemer, $18.50 to $19; Jackson County and Kentucky Silvery, 6 to 8% Silicon, $20.30 to $22.30; Jackson County and Kentucky Silvery, 10% Silicon, $23.30; Alabama Basic, $17.15 to $17.40; Virginia Basic, $17.15 to $17.40.
Pittsburg—Bessemer at Valley furnace, $15.50; Foundry iron, Northern No. 2, $16 to $16.50; at furnace; Northern forge, $15.15 at Valley furnace.
Cast-Iron Pipe:
New York—Carload lots, net tons, 6 to 10 ins., at tidewater, $26.50 to $27.
Chicago—4-in. water pipe, $28.50; 6-in. and heavier, $27.50 with $1 extra for gas pipe.

MISCELLANEOUS MATERIALS—
Asphaltum:
Ventura and other California asphalts, $20 to $21 per ton at New York; Trinidad refined, $25 to $30 per ton; Venezuela asphalt, $25 to $30 per ton; Bermuda asphalt, $25 to $30.
Cement:
Rosendale, in wood, $1; Portland, domestic, $1.70 to $1.80; Foreign brands, $2.25 to $2.50.
Copper:
Lake, 15.25 to 15.37½ cts.; electrolytic, 15.12½ to 15.25 cts.; casting, 14.87½ to 15 cts.
Lead:
New York, spot, 4.50 to 4.60 cts.
Spelter:
New York, spot, 6.10 to 6.20 cts.
Tin:
New York spot, 28.50 to 28.95 cts.

LUMBER—
New York, wholesale prices:
Piling—Spruce, ordinary cargoes, 5 to 6 cts.; oak, 14-in. butt, 40 to 50 ft., 19 cts.; 50 to 55 ft., 22 cts.; cts.; 6 × 8 ins. × 8 ft., 53 to 55 cts.; 7 × 9 ins. × 8 ft., 50 ft. and up, $16.
Railroad ties—Yellow pine, 6 × 9 ins. × 8 ft., 58 to 60 65 ft., $8.50; 65 to 70 ft., $9.50; 70 to 75 ft., $10.50; 55 to 60 ft., 23 cts.; 60 ft. and up, 25 cts.; pine, 60 to 62 to 64 cts.; 7 × 8 ins. × 8½ ft., 57 to 59 cts.; 7 × 9 ins. × 8½ft ., 64 to 66 cts.

PERSONAL.

Mr. E. T. Fishwick has resigned his position as General Sales Manager of the International Steam Pump Co.

Mr. Charles W. Lacy has been appointed Superintendent of Water-Works of Tishomingo, Ind. T.

Mr. Harry Z. Bikler has been appointed Chief Engineer of the plants of the Republic Iron & Steel Co., at Youngstown, O.

Mr. Dana Fernald has opened on office at 45 Broadway, New York City, for his practice as a Consulting Electrical Engineer.

Mr. R. B. Eggleston has been appointed Chief Engineer of the Plum Bayou Levee District, with headquarters at England, Ark.

Mr. B. B. Stakemiller has been appointed Engineer Maintenance of Way of the Illinois Terminal R. R., with headquarters at Alton, Ill.

Edward Lynch has been elected Superintendent of Water-Works system of Penn Yan, N. Y., to succeed Mr. Michael F. Buckley, resigned.

Mr. Burt W. Flint and Miss Marion G. Curry were married, Feb. 15, at Stoneham, Mass. Mr. Flint is a civil engineer located at Waltham, Mass.

Mr. Jno. W. Maxcy, of Houston, Tex., has been elected Superintendent of Roads, Bridges and Buildings of Harris County, Texas, for the ensuing two years.

Mr. P. A. Bivins, of Toledo, O., Engineer in charge of the Toledo & Indiana Ry., has accepted a position as Assistant to the Chief Engineer of the Wabash R. R.

Mr. Oscar Sanne, Assistant Engineer of the Scherzer Rolling Lift Bridge Co., Chicago, has been seriously ill with pneumonia, but is now recovering, after an illness of some weeks.

Mr. R. A. Campbell has been appointed Manager of the Asheville Line of the Southern Ry., with headquarters in the Chemical Bldg., St. Louis, Mo., vice Mr. Edwin Fitzgerald, deceased.

Mr. George H. Webster, formerly Division Engineer of the Canadian Pacific Ry., at Vancouver, B. C., is now President and Engineer of the British Columbia General Contract Co., of Vancouver.

Mr. W. L. Derr, Chief Engineer of the Erie R. R., has taken charge of the Susquehanna Division of that road, as Acting Superintendent, owing to the continued serious illness of Mr. W. J. Sharp.

Mr. Edward F. Neukon has been appointed Chief Engineer and Manager of the Bates Machine Co., of Joliet, Ill. Mr. Neukon formerly was Mechanical Engineer of the Brown-Corliss Engine Co.

Mr. William S. Parker and Mr. Robert W. Renton have formed a partnership under the firm name of Parker & Renton, and have opened offices in the Hammond Bldg., Detroit, Mich., for the practice of engineering.

Mr. Walter H. Graves and Mr. Frank P. King have formed a partnership, under the firm name of Graves & King and have opened offices in the Pierce Block, Boise, Idaho, for the practice of civil and hydraulic engineering.

Mr. Silas B. Patterson and Miss Mary E. Bull were married, Feb. 21, at Oxford, N. Y. After a short stay in this country, Mr. and Mrs. Patterson will return to Manila, Mr. Patterson being the Assistant City Engineer of that municipality.

Mr. T. C. Moorshead who was recently appointed Superintendent of the Litchfield & Madison Ry., with headquarters at Edwardsville, Ill., was formerly Chief Engineer of the Illinois Terminal R. R., and, with his resignation, that office was abolished.

Mr. Lindsay Duncan, Assoc. M. Am. Soc. C. E., of Denver, Colo., has been retained by the Taylor-Moore Construction Co., as Engineer in connection with their contract to drive the Gunnison Tunnel for the U. S. Government, and is now located at Montrose, Colo.

Capt. J. Francis Le Baron, M. Am. Soc. C. E., has been appointed Chief Engineer of the Louisville, Cumberland & Chattanooga R. R., This railroad will be 200 miles in length and will run through the center of the great Tennessee coal field on the Cumberland Plateau.

Mr. J. E. Breen has been appointed City Engineer of Cincinnati, O., to succeed the late H. J. Stanley. Mr. Breen has been acting City Engineer since Mr. Stanley became ill last November. Previous to his new appointment Mr. Breen was Superintendent of Track Elevation and Subways.

Mr. Frank Henderson, General Manager of the Great Southern Ry. of Argentina, will sail from that country March 24 for England and America. Mr. Henderson will be one of the Argentine representatives at the International Railway Conference to be held at Washington, D. C., in May.

Mr. Wm. B. Wheeler has been appointed General Manager of the Railroad and Marine Department of Toch Brothers, manufacturers and importers of paint, and will have his headquarters in the Fisher Bldg., Chicago, Ill. Mr. Manton E. Parker is General Manager of the same department located in New York.

Mr. Charles W. Cross, formerly of the Roberts & Abbott Co., Consulting Engineers of Cleveland, O., and later Electrical Engineer for the Eastern Ohio Traction Co., has entered the employ of Crocker-Wheeler Co., of Ampere, N. J., and is attached to the Cleveland Office of the company at 816 New England Building.

Mr. Thomas McBride has been elected Secretary of the Thomas Carlin's Sons Co., of Allegheny, Pa., manufacturers of hoisting engines and contractors' machinery, succeeding Mr. William C. Scott, formerly Secretary and Treasurer, who has left the employ of the company. Mr. McBride will perform the duties of Treasurer, pending the filling of that office by the Directors.

Mr. F. A. Molitor has been appointed Chief Engineer of the Midland Valley R. R., with office in St. Louis, Mo., and will have charge of all matters pertaining to construction. Mr. J. F. Elder has been appointed General Manager of the above road, and will also have charge of all matters pertaining to traffic. The combined office of Chief Engineer and General Manager has been abolished, as has the office of Traffic Manager.

The Engineering Corps for the purposes of building the New York, Westchester & Boston Ry. has been practically completed as follows:

Mr. William A. Pratt, M. Am. Soc. C. E., formerly Chief Engineer of the Staten Island Rapid Transit R. R., will be Chief Engineer.

Mr. William Barclay Parsons, M. Am. Soc. C. E., and Mr. John Bogart, M. Am. Soc. C. E., formerly New York State Engineer, will be the Consulting Engineer.

Mr. George Tatnall, M. Am. Soc. C. E., has been engaged as Principal Assistant Engineer, and will have charge of all general engineering matters, under the supervision of the Chief Engineer.

Mr. James Leland Crider, hitherto in charge of elevating tracks and eliminating grade crossings of the Baltimore & Ohio R. R., in Pittsburg, Pa., is to be Division Engineer of that portion of the line in the Borough of the Bronx and the "Annex" District. He will have immediate charge of the field corps on location and construction.

Mr. E. V. Maitland, who has had charge of the work of elevating the Pennsylavnia R. R. tracks through the cities of Chester and Wilmington, will be Resident Engineer in the Borough of the Bronx.

Mr. E. B. Naylor, who has been Engineer in the construction of the subway tunnel for the Rapid Transit Subway under the Harlem River, is to be Resident Engineer in charge of the branch of the road from the New York City limits to White Plains. The names of the Engineer of Structures and the Electrical Engineer are to be announced shortly.

Obituary.

Charles B. Combs, a civil engineer, died recently at the home of his son-in-law in Sherburne, N. Y.

James J. McDonald, a well known contractor of Ansonia, Conn., died Feb. 27, aged 66 years.

James Clark, President of the Osgood Dredge Co., of Albany, N. Y., died Feb. 21, at his home in that city, after an illness of about a week.

Calvin Detrick, a contractor who built the first electric lighting plants of Richmond Borough, died Feb. 18 at his home in Brooklyn, N. Y. Up to about three years ago he was President of the Staten Island Light, Heat & Power Co. He was 67 years old.

Charles P. Simmons, President of the Simmons Keystone Water Filter Co., died suddenly Feb. 25, at the Hotel Earlington, New York City. Mr. Simmons, who was 52 years old, was a resident of Baltimore, but since the death of his wife, three weeks ago, he had been living at the Earlington.

John McGilvray, for 24 years Dockmaster of the graving docks at the Erie Basin, Brooklyn, N. Y., died Feb. 23, at his home in Brooklyn. Mr. McGilvray built the marine railways at Hunter's Point, N. Y., and the bridge across Newtown Creek at that place. In 1865 he built a marine railway in the Bermudas.

Dr. Albert Benjamin Prescott, Director of Chemical Laboratories of the University of Michigan, Professor of Organic Chemistry, and Dean of the School of Pharmacy, died Feb. 23 at Ann Arbor, Mich., aged 72. He formerly was President of the American Association for the Advancement of Science and the American Pharmaceutical Association.

Edward Longstreth, a former Vice-President of the Franklin Institute, died Feb. 24, at his home in Philadelphia, Pa. Mr. Longstreth entered the employ of the Baldwin Locomotive Works in 1850 as an apprentice. In 1867 he was made General Superintendent of the Works, and in 1870 he was admitted to a partnership. He was associated with the firm until his retirement in 1886. He was born in 1839.

Frederick John Warren, of Cambridge, Mass., President of Warren Brothers Co., of Boston, Mass., died suddenly at Hotel Essex, Boston, Tuesday, Feb. 21, about 2 P. M. Mr. Warren had been spending several days in New York with his wife and arrived in Boston at 7 A. M. on the day of his death. After breakfasting with his wife at Hotel Essex, Mrs. Warren went to their home at Cambridge, Mass., and Mr. Warren took a room at the Essex after telephoning his office that he was feeling tired and would take a rest and be at the office about 11 o'clock. As he did not come to the office and there were some matters requiring his attention, one of his brothers went to his room and found him on the bed apparently lifeless. Dr. J. H. Stevens was immediately called and responded in a few moments, and after a careful examination pronounced life extinct and said that he had probably passed away a few minutes before in his sleep. His body was in a remarkably easy position. Last evening he expressed himself to Mrs. Warren as being tired, but was otherwise apparently well and in good spirits. Mr. Warren's business was in excellent condition, but he had become run down through overwork, though his family and business associates did not consider his condition serious. Mr. Warren was a son of the late Herbert M. Warren, of Newton, Mass., and was born at the family residence in that city on Feb. 18th, 1865, and had, therefore, just passed his fortieth birthday. He left a wife and a daughter, aged twelve. Mr. Warren was formerly connected with the Warren-Scharf Asphalt Paving Co., and when that company was absorbed by the Asphalt Trust, some years ago, he and his associates undertook to exploit the bitulithic paving, on which he held patents. His success in establishing this new industry in the face of prejudice and strong competition was phenomenal.

Philip G. Eastwick, whose death, of yellow fever, at Panama, Feb. 1, was mentioned briefly in our issue of Feb. 9, was born in Philadelphia in 1838. He was the son of Andrew M. Eastwick, the well-known engine builder and manufacturer, who under an Imperial government contract, constructed practically the first railway in Russia. Mr. Eastwick served for several years in that country with his father on this work, and there acquired a large part of such knowledge and experience which later gave him his reputation as a civil engineer. As a naval engineer Mr. Eastwick's services date back to the Civil War, he having been with Farragut at Mobile and New Orleans. After the close of the war he went to Oregon and Washington, the latter being then a territory. Seattle at that time was a place of small importance, but with great expectations, and he was called upon to make the first survey of the future city and establish street grades. Later on in the seventies he was engaged in making definite location for the Northern Pacific R. R. across the great plain of the Columbia River, between the mouth of Snake River and Spokane Falls. In the early eighties he was Assistant Engineer in charge of the construction of the government jetty at the mouth of the Columbia River. Other important government engineering projects upon which he was engaged were the removal of obstructions from the Upper and Lower Snake River and of the Okanogan River. In 1890-91 he was charged with the important survey of the Lake Washington and Puget Sound Ship Canal, now under construction. At the commencement of the Spanish-American War he was Resident Engineer in charge of the construction of the main, mortar and rapid-fire batteries at Fort Casey, Wash. Of late years he has been engaged in irrigation projects, both in the States of Oregon and Idaho, and in the practice of his profession generally. He was Engineer Officer with the rank of Major on the Staff of Governor Lord of Oregon, during his term of office; he was also a prominent member of the Loyal Legion of the United States. Mr. Eastwick was a civil engineer of the old school and very thorough in everything and has left a record of perfect straightforwardness in all his dealings. He was 65 years old at the time of his death, and leaves a widow in Portland, and two sons, Philip and Benjamin, the former in Panama and the latter in Portland. Mr. Eastwick's remains were interred at Panama; the quarantine regulations not permitting their removal, until a stipulated period, when they will be taken to Portland, Ore., for final interment.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 21, 22, 23. Annual meeting at Chicago. Secy., L. C. Fritch, 1502 Monadnock Block, Chicago.

AMERICAN ELECTROCHEMICAL SOCIETY.
April 25 to 27. Annual meeting at Boston and Cambridge, Mass. Secy., S. S. Sadtler, 39 South 10th St., Philadelphia, Pa.

AMERICAN WATER-WORKS ASSOCIATION.
May 8 to 12, 1905. Annual meeting at West Baden, Ind. Secy., J. M. Diven, Charleston, S. C.

INTERNATIONAL RAILWAY CONGRESS.
May 3 to 15, 1905, at Washington, D. C. Secy. of American Committeee, W. F. Allen, 24 Park Place, New York.

{MASTER CAR BUILDERS' ASSOCIATION.
{AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-21, 1905. Annual meeting at Manhattan Beach, N. Y. Secy., J. W. Taylor, The Rookery, Chicago, Ill.

ENGINEERS' CLUB OF PHILADELPHIA.—A paper on "Engineering Development of Manila Under American Dominion," by Mr. R. G. Dieck, will be read at the next meeting, March 4, 1905. The paper will be illustrated with lantern slides. Secy., W. L. Webb.

CIVIL ENGINEERS' CLUB OF CLEVELAND.—The present year is the twenty-fifth anniversary of the club's existence, and in celebration the club will have a special banquet on the evening of March 13. Mr. Ambrose Swasey is chairman of the committee in charge of the celebration.

BROOKLYN ENGINEERS' CLUB.—The next regular meeting will be held at the club rooms, 197 Montague St., Brooklyn, N. Y., on March 9, 1905. Mr. L. T. Haney will read a paper on "Precise Spirit Leveling; A Description of Instruments, Methods and Results," which will be illustrated with lantern slides. Secy., Jos. Strachan.

NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.—At the annual meeting, which was held at Young's Hotel, Boston, Mass., on Feb. 15, the following officers were elected to serve during the coming year: President, Mr. F. S. Richardson, North Adams, Mass.; Vice-Presidents, Messrs. Wm. McGregor, of Pawtucket, R. I., and W. G. Africa, of Manchester, N. H.; Secretary, Mr. N. W. Gifford.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.—The election of officers at the annual meeting, held at New Haven, Conn., on Feb. 14 and 15, resulted in the ratification of the official nominees, as follows: President, Mr. Albert B. Hill, of New Haven; Vice-Presidents, Messrs. W. T. Spencer, of New Haven, and Charles F. Chase, of New Britain; Secretary, Mr. J. F. Jackson, of New Haven. The society has at present a membership of 200, and its cash assets are over $900.

ENGINEERING ASSOCIATION OF THE SOUTH.—The Nashville Section met at the association rooms on the evening of Monday, Feb. 20, with good attendance. Prof. C. S. Brown presented a paper on "The Coming Prime Mover," which was a discussion of the modern gas engine. After the reading of the paper the subject of wide tires was discussed, and as a result a committee, composed of Messrs. W. W. Southgate, E. C. Andrews, C. A. Locke, E. C. Lewis and L. C. Glenn, was appointed to report on the question whether or not an improvement of roads might be expected from the general use of wide tires on vehicles.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The February reunion, which had been scheduled for Tuesday evening, Feb. 28 (last Tuesday of month), has been postponed to Thursday, March 2. Mr. W. R. Warner, of Cleveland, O., will lecture on "The Conditions at Panama and the Reasons for a Sea-Level Canal." Reunions will be held also on the last Tuesdays of March, April and May. At the March meeting Prof. Barnes, of McGill University, Montreal, will address the society on "Some Experiments connected with Phenomena of Ice Below the Surface of Water in Streams." At the April meeting Mr. James M. Dodge will speak, and at the May meeting Mr. G. C. Henning will lecture on "Manufacture and Use of Diamond Tools."

NEW ENGLAND WATER-WORKS ASSOCIATION.—The March meeting of this association will be held at its headquarters in Tremont Temple, Boston, on Wednesday, March 8, 1905, the professional meeting convening at 2 p. m. The committee on Meter Rates (Mr. Freeman Coffin, Ch.) will report, and four papers will be read, as follows: "Test of Large Meters and Fire Supply Services," by Mr. W. F. Sullivan, of Lowell, Mass.; "The Mississippi River as the Source of Water Supply for the Inhabitants of the Mississippi Valley," by Prof. Erastus G. Smith, of Beloit, Wis.; "The Chicago-St. Louis Drainage Canal Case," by Prof. W. T. Sedgwick, of Boston, Mass.; and "A Visit to Some Interesting Municipal Water Filters Now Under Construction," by Mr. C. E. A. Winslow, of Boston, Mass. Secy., Willard Kent, Narragansett Pier, R. I.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—At the meeting of Feb. 24, 1905, held at 12 West 57th St., New York City, two papers were read, "Two-Motor versus Four-Motor Equipments," by Mr. N. M. Crawford, of Hartford, Conn., and "Track Bonding," by Mr. C. W. Ricker, of New York, N. Y. The first paper purported to present an experimental comparison of earning value or "commercial efficiency" of two-motor and four-motor cars differing in size and powering; but the actual figures worked out are valueless because they have little or no relation to operating expense or profit-earning power. Experimental results of energy consumption of the different cars over the same line are presented; these are, however, largely affected by the different gear-ratios employed, as half of the cars were overgeared and hence consumed excessive starting energy. The discussion, mainly by Messrs. A. H. Armstrong and S. T. Dodd, stated the present-day tendency toward four-motor equipments, and explained it by the urgent requirement in city work for maximum adhesion, and in interurban work for maximum power. The test results showing much higher energy consumption per ton-mile in two of the cars tested by the author were criticized because of differences in weight, powering and gearing.

The second paper gave an excellent review of the methods of bonding track-rails, and analyzed their advantages and disadvantages. Special attention was directed to the great deterioration of most bonds in a short life, and to the necessity of extremely careful work in installation to guard against it. Cost figures were given for two cases of bonding, the labor cost in one case being 27.5 cts. per bond and in the other case 12 cts. per bond. Mr. H. A. Lardner, in discussion, expressed the belief that a radically new type of bonding will have to be devised for heavy electric traction work of the future; he bases this belief on the great dependence of satisfactory contact on the workman, and the practical impossibility of ensuing reasonably durable contact at every bond.

WESTERN SOCIETY OF ENGINEERS.—At the meeting held at the society's rooms in Chicago on Feb. 15, Mr. W. H. Blauvelt, of the Semet-Solvay Co., Syracuse, N. Y., read a paper on "By-Product Coke Ovens." Broadly speaking, there are two methods in use for producing coke: (1) Distillation with admission of air into the coking chamber, and a partial combustion of the fixed carbon of the coal as well as of the volatile matter; (2) Distillation in a closed chamber, where no air is admitted and the heat enters through the walls. The latter is a true distillation, and no part of the coal is consumed in the process. In 1855 coke ovens saving the tar and ammonia were successfully operated by Pauwels, Dubochet and Knab. A few years later Carvès added side-flues to Knab's oven, but it was not until 1881 that the condensation of ammonia and tar was a success in combination with the production of a good quality of coke. In 1870 two plants were supplying illuminating gas in Paris, but it was of a low illuminating power and had to be enriched with bench gas. An oven with horizontal flues in the side walls was designed by Huessener, in Germany, and one with vertical flues by Coppée, in Belgium. The several different types of by-product ovens have all sprung from three sources: (1) The modified beehive oven (itself a development of the charcoal burners' oven); (2) the Coppée oven, the forerunner of the Otto type, and (3) the Knab-Carvès oven, the ancestor of the Semet-Solvay type.

In the retort oven the coking chamber is long and narrow—30 to 40 ft. long, 6 to 9 ft. high and 16 to 20 ins. wide. This will coke many coals that cannot be coked in a beehive oven. In some European plants, where the available coal did not produce a coke of sufficient density or strength, the coal is compressed into a coke before being charged into the oven. The oven is emptied by a heavy ram on a long beam operated from a carriage traveling along the front of the battery of ovens. The coking process occupies from 18 to 36 hours, depending on the quality of the coal and the width of the oven. Various coals are most effectively coked by higher or lower heats, or longer or shorter periods of coking. Sometimes a mixture of coal gives the best coke, or a fine grinding may be necessary to produce a good texture.

The crude oil produced is the source of a multitude of "coal-tar products," the principal being anthracene, naphthalene, creosote, carbolic acid and benzol. The by-product ovens in this country are already the leading producers of ammonia, while considerable attention is being given to the production of illuminating gas from these ovens.

There are now over 3,000 by-product ovens in operation or under construction, with a capacity of about 4,750,000 tons of coke per annum.